BANISTERIA

A JOURNAL DEVOTED TO THE NATURAL HISTORY OF VIRGINIA

Twinleaf (*Jeffersonia diphylla*)

The genus *Jeffersonia*, which contains one species each in eastern North America and Asia, is named for Thomas Jefferson (1743-1826), third President of the United States and the subject of the lead article in this issue containing the proceedings of the Virginia Natural History Society's symposium entitled "Historical Explorations into Virginia's Natural History."

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B A N I S T E R I A

A JOURNAL DEVOTED TO THE NATURAL HISTORY OF VIRGINIA

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The Virginia Natural History Society (VNHS) is a nonprofit organization dedicated to the dissemination of scientific information on all aspects of natural history in the Commonwealth of Virginia, including botany, zoology, ecology, archeology, anthropology, paleontology, geology, geography, and climatology. Membership in VNHS includes a subscription to *Banisteria*. Annual dues are $20.00 (per calendar year); library subscriptions to *Banisteria* are $40.00. Subscribers/members outside the United States should add $3.00 for additional postage. **Checks should be made payable to the Virginia Natural History Society**. Membership dues and inquires should be directed to the Secretary-Treasurer (address, page 3); correspondence regarding *Banisteria* to the Editor. *Banisteria* is a peer-reviewed journal. The Editor will consider manuscripts on any aspect of natural history in Virginia or neighboring states if the information concerns a species native to Virginia or the topic is directly related to regional natural history (as defined above). Book reviews, biographies, and historical accounts of relevance to natural history in Virginia also are suitable for publication in *Banisteria*. For additional information regarding the VNHS, including other membership categories, field events, symposia, representative papers from past issues of *Banisteria*, and instructions for prospective authors, consult our website at: **http://virginianaturalhistorysociety.com/**

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Cover: *Jeffersonia diphylla,* engraving of a drawing by William Bartram and Benjamin Smith Barton of a plant collected by André Michaux in 1789 near the headwaters of the Roanoke River in the Blue Ridge Mountains of Virginia (source: Benjamin Smith Barton. 1793. A botanical description of the *Podophyllum diphyllum* of Linnaeus. Transactions of the American Philosophical Society 3: 334-348, plate 1).

Back cover: *Stenolemus lanipes* (Heteroptera: Reduviidae); free-hand drawing by Richard L. Hoffman.

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Number 41, 2013

"Historical Explorations into Virginia's Natural History"
Proceedings of a VNHS symposium held on September 26, 2009
at the Virginia Museum of Natural History, Martinsville, Virginia

Contributed Papers

Shorter Contributions

Attendees of the Virginia Natural History Society's symposium entitled "Historical Explorations into Virginia's Natural History" held on September 26, 2009 at the Virginia Museum of Natural History in Martinsville.

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Symposium Summary

The Virginia Natural History Society's symposium entitled "Historical Explorations into Virginia's Natural History", which was held on September 26, 2009, was a big success! The new Virginia Museum of Natural History in Martinsville provided the perfect venue for the 60 people who attended the symposium. Talks began at 8:30 AM and ended twelve hours later with our sadly deceased co-founder, Dr. Richard Hoffman's keynote address, "Nature, Natural History, and Naturalists in Virginia Since 1927, a Personal Evaluation." Talks ranged from Thomas Jefferson's contributions to recently discovered mussel biology to botanical work done nearly 400 years ago. This symposium brought together people from across the state who share a passion for natural history where ideas and information could be shared face to face. This issue of *Banisteria* includes six articles made by the 13 presenters at the symposium. In addition, a paper on the history of wildlife management in Virginia was prepared after the symposium and is included as part of the proceedings. A presentation was made by Donna Ware at the symposium on the history of botany in Virginia and an expanded history was coauthored with Nancy Ross Hugo in the new *Flora of Virginia*.

Thanks to all of the people who helped organize the symposium:

Program Committee Members: Richard Hoffman, Barry Knisley, Michael Kosztarab, Joe Mitchell, Steve Roble, and John White.

Sponsors: Virginia Museum of Natural History, Virginia Native Plant Society, Virginia Herpetological Society, and Virginia Academy of Science.

The Society also thanks Beckie Smith and Bill Shear who took care of the mail-in registrations; Carolyn Seay of the Virginia Museum of Natural History; Lynn Pritchett, a Master Naturalist volunteer, who was in charge of the registration table during the event; and Dutch Inn who catered the symposium.

Presentations (* = published in symposium proceedings):

*Abraham, B. J. Hampton University. Araneology in Virginia.

Henika, W. S. Virginia Tech. Anna Isabel Jonas: Pioneer in Petrotectonics.

Hilton, E. Virginia Institute of Marine Science. History of Marine Ichthyology in Virginia.

Jones, J. Virginia Tech. Natural History and Conservation of Freshwater Mussels in Virginia.

*Hoffman, R. Virginia Museum of Natural History. Nature, Natural History, and Naturalists in Virginia Since 1927, a Personal Evaluation.

Kosztarab, M. Virginia Tech. Studies on the Terrestrial Insects of Virginia.

*Mitchell, J. Mitchell Ecological Research Service. Emmett R. Dunn and the Origin of Virginia Herpetology.

*Rose, B. Old Dominion University. The Mammals.

*Stanton, L. Shannon Senior Historian Monticello. Thomas Jefferson, Naturalist.

Ward, L. W. Virginia Museum of Natural History. Virginia's First Fossil Collections; the Earliest Known from North America.

Ware, D. College of William and Mary Herbarium. Plant Exploration and Herbarium-building in Virginia, 1900 to the Present.

*Winston, J. W. Virginia Museum of Natural History. History of the Study of Marine and Estuarine Biology in Virginia.

Yemm, T. American Lives: History Brought to Life™. Death of the Dilettante: The Evolution of Botanical Study in the First Three Hundred Years of Virginia's Settlement by Europeans.

Tom McAvoy, Program Coordinator

Program coordinator Tom McAvoy (far left) and symposium speakers (left to right) Lauck Ward, Judy Winston, William Henika, Bob Rose, Richard Hoffman, Jess Jones, Michael Kosztarab, Barb Abraham, Terry Yemm, Cinder Stanton, Eric Hilton, Donna Ware, and Joe Mitchell.

Banisteria, Number 41, pages 5-16

Thomas Jefferson and Virginia's Natural History

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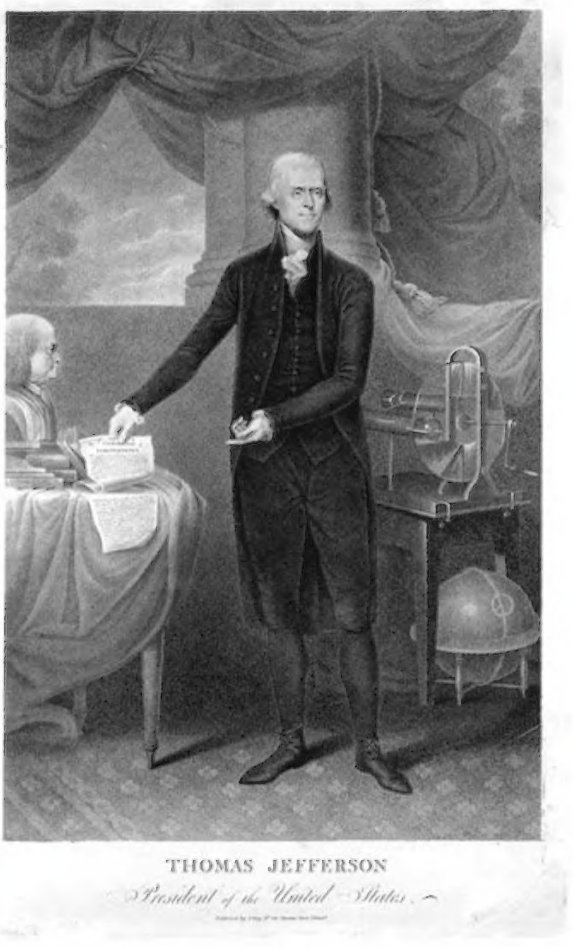
ABSTRACT

In forty years as a public servant, Thomas Jefferson often lamented being a "prisoner of state." He described natural history as his passion and, when tied to his desk by political duties, he longed to be out in the "rich fields" of nature, studying grain weevils or noting the blooming dates of flowers. Jefferson had a lifelong fascination with the flora and fauna of Virginia and a reputation for a wide knowledge of botany and zoology. This paper focuses primarily on Jefferson's interest in and interactions with birds, insects, and plants, particularly those of his own state.

On April 16, 1803, the President of the United States was in his study in the White House, writing down these words: "3. house flies of ordinary size to-day." Thomas Jefferson made this observation in a weather diary in which he had been recording the temperature of his nation since its birth in July 1776. Besides taking readings of his thermometer, he noted other "indexes of climate" — biological events, like the flowering of plants, falling of leaves, and the comings and goings of birds and insects, which marked the cycle of the seasons. Throughout his presidency, he jotted down more signs of spring than just house flies. Such entries included "redbreasts" (7 March 1804), "weepg. willow leafing" (9 March 1808), "frogs sing" (12 March 1807), "shad at table" (19 March 1808), "martins appear" (1 April 1806), "whippoorwill" (2 April 1805), "dogwood blossomd." (7 April 1807), and "Magnolia glauc. blossoms" (24 May 1807).[1]

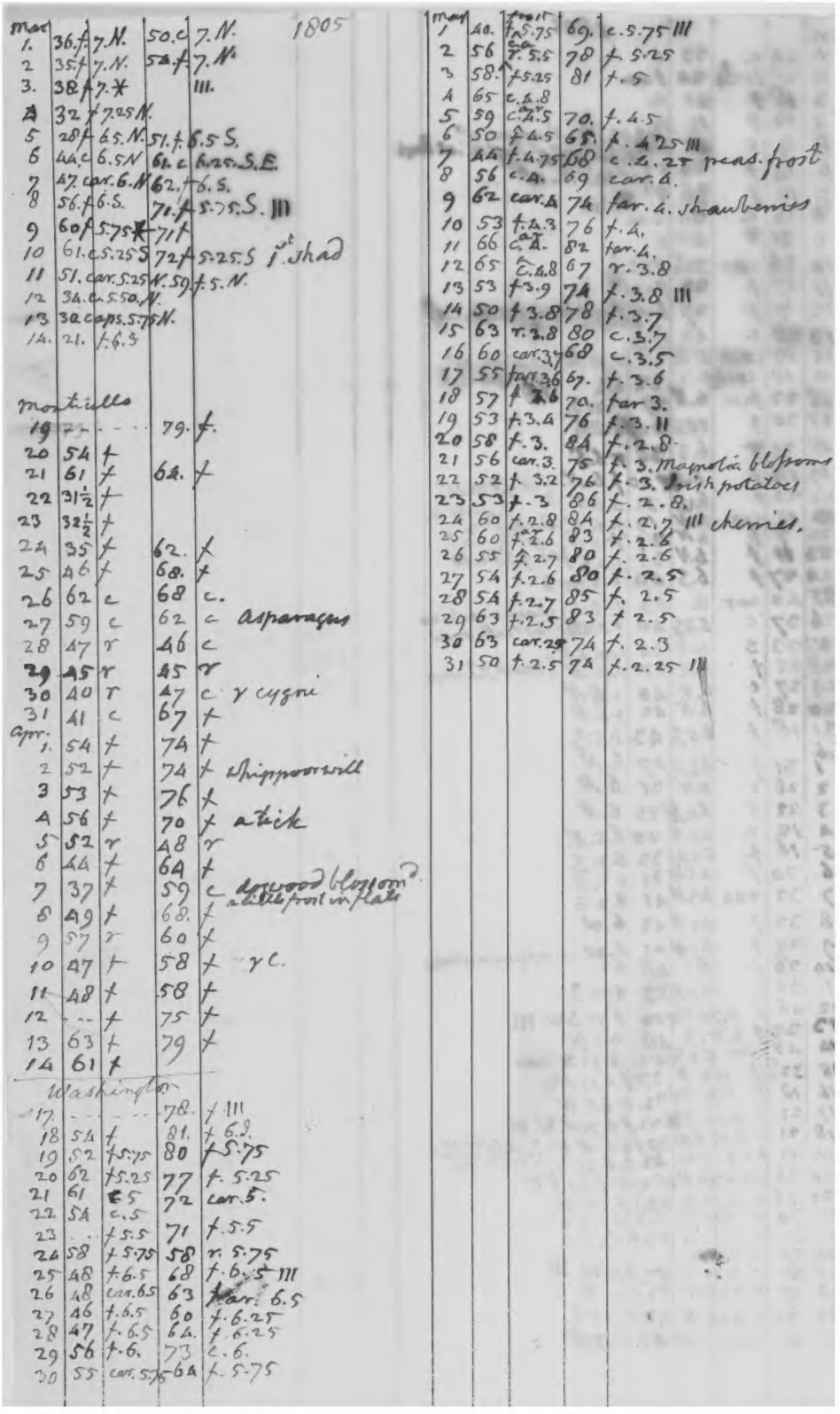
Jefferson's exercises in phenology — a word coined later in the century[2] — provided one way to engage with the natural world during his eight trying years as the nation's chief executive. For the most part, however, he lamented that his public duties left no time



President Jefferson, engraving by Cornelius Tiebout, 1801.

[1] Jefferson's weather memorandum book, p. 2 and passim, Massachusetts Historical Society (hereafter WMB); Jefferson to Lewis E. Beck, 16 July 1824, Albert Ellery Bergh, ed., *The Writings of Thomas Jefferson* (Washington, 1907) 16: 71-72.

[2] Belgian botanist Charles Morren first used the term about 1850 (Gaston R. Demarée and This Rutishauser, "Origins of the Word 'Phenology,'" *Eos* 90, no. 34 [2009], 291).



Jefferson's notations in the spring of 1805 in his weather memorandum book, 1782-1826, p. 10 (Courtesy of the Massachusetts Historical Society).

for close study of nature. In 1802, after physician-naturalist Benjamin Smith Barton wrote of his plan to gather information on natural history and Indian languages in the southern Appalachians, Jefferson responded: "I really envy you your journey; but I am a prisoner of state." Five years later he said that his public service had prevented him from indulging "in the rich fields of nature, where alone I should have served as a volunteer, if left to my natural inclinations and partialities."[3]

Jefferson's broad interest in and knowledge of the field of natural history is well known, as is his extensive library on the topic. Throughout his life, he kept in touch with a worldwide network of naturalists and he was particularly fascinated by nature on his own continent. He sponsored fact-gathering expeditions across it and patriotically defended it in his one published book — *Notes on the State of Virginia* — which was, in large part, a work of natural history. Yet, even before his presidency, Jefferson had seldom been able to pay attention to a pursuit he described as "my passion."[4] The constraints of forty years of public service meant that he was more of a lending librarian and scientific cheerleader than a contributing naturalist. He counseled and encouraged his countrymen, promoting and publicizing their collecting and publishing efforts. His own observations over the years, propelled by patriotic zeal, Enlightenment faith, and an encyclopedic curiosity, reflected his conviction that science was a tool for advancing the fortunes of the new nation as well as improving the entire human condition.

Jefferson's weather records — alas the closest thing to a diary we have from his pen — were partly motivated by his perennial combat against a "very degrading" theory of the Comte de Buffon and other European scientific authors. Their belief that animals in the New World were undersized versions of their European counterparts was underpinned by a conviction that this inferiority was the result of a humid and unhealthy American climate.[5] Therefore, besides his efforts to assemble proofs of the large size of American mammals, Jefferson became a one-man weather station and enlisted scientifically-minded friends and relatives in the quest to redeem the continent through comparative meteorological records. He periodically compiled observations made over a range of years into charts, to show the prevailing winds or, in the case of his phenological records, to provide an "estimate of the climate ... made from the advance of the spring, as manifested by animal & vegetable subjects."[6]

Without venturing into the American West with Lewis and Clark or treating Jefferson's role in other national enterprises of natural history, this paper focuses principally on ways in which he interacted directly with the fauna and flora of his own state. His most intense engagement with Virginia's natural history was in the early 1780s, when he was preparing what became his *Notes on Virginia*. In his zealous defense of the American continent from the European theory of degeneration of animal life, he enlisted friends to provide "the heaviest weights of our animals ... from the mouse to the mammoth" and took out his own scales on occasion, once noting: "I weighed a black squirrel 1 lb. - 2¾ oz." Americans overwhelmed the European competition in his published tables of comparative weights of quadrupeds.[7]

Birds

In July 1782, with a different aim, Jefferson weighed several birds to the nearest gram. This was part of an effort to add to the meager store of scientific descriptions of American birds and to clarify some of the confusion in nomenclature. He closely examined a few birds that did not quite match what he saw in his copies of Linnaeus's *Systema Naturae* (1758-1759) and

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[3] Jefferson to Benjamin S. Barton, 29 March 1802, Julian P. Boyd et al., *The Papers of Thomas Jefferson* (Princeton, 1950–) 37: 132 (hereafter PTJ); Jefferson to Casper Wistar, 21 June 1807, Bergh, *Writings*, 11: 248.

[4] Jefferson to Harry Innes, 7 March 1791, PTJ 19: 521. In 1807 Jefferson wrote, "I view no science with more partiality than Natural history" (Jefferson to Jean de Lacoste, 24 May 1807, Bergh, *Writings*, 11: 206).

[5] Jefferson to Ezra Stiles, 10 June 1784, PTJ 7: 304. See also Keith Thomson, "Jefferson, Buffon and the Moose," *American Scientist* 96 (2008), 200-202.

[6] WMB; Edwin M. Betts, ed., *Thomas Jefferson's Garden Book, 1766-1824* (Philadelphia, 1944), 622-628. See also Susan Solomon, John S. Daniel, and Daniel L. Druckenbrod, "Revolutionary Minds: Thomas Jefferson and James Madison participated in a small 'revolution' against British weather-monitoring practices," *American Scientist* 95 (2007), 430-437.

[7] Jefferson to Thomas Walker, 25 September 1783, PTJ 6:339; Jefferson's notation on Thomas Walker's "Table of American Animals," among the loose notes and memoranda related to *Notes on Virginia*, Massachusetts Historical Society: Jefferson Papers; Thomas Jefferson, *Notes on the State of Virginia*, ed. Frank Shuffelton (New York, 1999), 50-61. Mammals are given short shrift in the present paper; for Jefferson's zoology debate with Buffon, see Keith Thomson, *Jefferson's Shadow: The Story of His Science* (New Haven, 2012), 62-73.

Mark Catesby's *Natural History of Carolina, Florida, and the Bahama Islands* (1731-1743). Jefferson then drafted and re-drafted descriptions of the birds in both Latin and English. He never published them, however, evidently deciding that what he called the "yellow titmouse" and the "Star-martin" (Eastern Kingbird) were best quietly slipped into the current taxonomy. They appear in a table in the *Notes on Virginia*, an enumeration of 126 species that one authority called "the first attempt to list all Virginia birds." Jefferson provided Linnaean and popular names and cited descriptions in Buffon's *Histoire Naturelle* (1749-1788) and Catesby's work, the source for more than ninety of the species he included.[8]

On Jefferson's birthday in April 1782, four French soldiers rode up Monticello mountain, accompanied by their six servants and a dog. One of the visitors, the Chevalier (later Marquis) de Chastellux, devoted a chapter of his book of American travels to his host. He recalled sitting up late over bowls of punch, discussing Scottish poetry and thorny issues of natural history. The climate and the correct assignment of nationality to animal species particularly engaged them, as they puzzled over the deer family and wondered if the rabbit was really an American species. Chastellux, who was surprised at how ignorant most Americans were of their own natural history, included in his *Travels* a long account of the Purple Martin. He and Jefferson debated the hot topic of where martins and swallows spent their winters. The Frenchman believed in migration, but Jefferson seems to have clung to the theory of torpidity or hibernation. He told Chastellux that an eminent Virginia judge had assured him that he had seen "a great number" of martins in a torpid state in a hollow tree.[9] A few years later, Jefferson made a list of interesting magazine articles that included Daniel Boone's journal, an English method of making cheese, and "testimony that the house swallows lie in winter at the bottoms of rivers." In a letter of 1796, he spoke of "the birds issuing from their state of torpor." The Purple Martin, the most frequently noted "index of climate" in his weather diaries, always "appeared" rather than "arrived."[10]

For Jefferson, birds were signs of spring, markers of the spread of civilization, and, in the case of his pet mockingbirds, "the delight of every hour." He noted the expanding range of the (Eastern) Meadowlark and the Mockingbird (a wild Mockingbird was first sighted at Monticello in the spring of 1793).[11] Since music was another of Jefferson's passions, it is not surprising that song was at the heart of his appreciation of birds. After hearing "a double row of nightingales ... in full song" in the south of France, he wanted to "colonize" this bird in America.[12] Mockingbirds were his principal pets throughout his life. His Washington friend Margaret Bayard Smith left a famous account of Jefferson's favorite mockingbird, "the constant companion of his solitary and studious hours," that would fly about his study and "regale him with its sweetest notes."[13] Another look into Jefferson's weather diary reveals that there was more than one mockingbird in the White

[8] Various notes on birds, among the loose notes and memoranda related to *Notes on Virginia*, Massachusetts Historical Society: Jefferson Papers; *Notes on Virginia*, 71-77; David W. Johnston, *The History of Ornithology in Virginia* (Charlottesville, 2003), 62. The citations to Buffon did not appear in the first edition of the *Notes*. The birds weighed in 1782 were the Eastern Kingbird, Red-eyed Vireo, Yellow-breasted Chat, a "Creeper" [Brown Creeper?], and the "yellow titmouse," most likely a warbler. I wish to thank Storrs Olson and Carla Dove for their help in efforts to identify this still mysterious bird.

[9] François Jean Chastellux, *Travels in North America in the Years 1780, 1781, and 1782*, ed. Howard C. Rice, 2: 392-396, 460-461. Chastellux wrote that "it would even now be a very useful thing to send to America a little caravan composed of naturalists, geographers, and draftsmen" (2: 458).

[10] Notes on Affairs of State: Miscellanea, Library of Congress: Jefferson Papers (the article on swallows was from the *American Museum* 1: 358); Jefferson to Thomas Mann Randolph, 29 February 1796, PTJ 28: 625; WMB passim; James A. Bear, Jr., and Lucia C. Stanton, eds., *Thomas Jefferson's Memorandum Books 1767-1826* (Princeton, 1997), 1: 756 (21 April 1790), 773 (5 April 1784); 2: 843 (21 April 1791), 1070 (2 April 1802).

[11] Jefferson to Etienne Lemaire, 25 April 1809, J. Jefferson Looney et al., eds., *The Papers of Thomas Jefferson: Retirement Series* (Princeton, 2004–) 1: 162 (hereafter PTJ-R); Jefferson weather memorandum book, 30 June 1778, Library of Congress: Jefferson Papers ("a field lark at Shadwell. the first I ever saw so far Westerly"); Thomas Mann Randolph to Jefferson, 22 May 1793, and Jefferson to Martha J. Randolph, 10 June 1793, PTJ 26: 87, 250.

[12] Jefferson to William Short, 21 May 1787, PTJ 11: 372. The birds and animals Jefferson wished to introduce to the United States included the Skylark, Nightingale, Red-legged Partridge, Angora cat, and unspecified hares and rabbits. His various efforts to carry out this project were unsuccessful. For a representative sampling from the many letters on the topic, see Jefferson to Archibald Cary, 7 January 1786, James Monroe, 26 May 1795, and William Thornton, 11 October 1809, PTJ 9: 158, 28: 362, PTJ-R 1: 599-600.

[13] Margaret Bayard Smith, *The First Forty Years of Washington Society*, ed. Gaillard S. Hunt (New York: Scribner, 1906), 385.

House. Each year he noted their inaugural vocalizations as part of his phenological record. In 1808, for instance, the "[New] Orleans bird sings" on January 23. A week later "the old mock. bird sings." On March 2, "the middle aged bird sings," and the next day "Dick sings." The only named mockingbird in his writings, Dick was probably the favorite described by Mrs. Smith. The songs of this bird, which perched on Jefferson's writing table and hopped up the stairs after him when he retired for a nap, may have included "Willie Was a Wanton Wag." The tune of this Scottish song had been borrowed for one of the most popular patriotic songs of the day, "Jefferson and Liberty." Based on their price (the equivalent today of several hundred dollars each), two of Jefferson's birds must have received singing lessons prior to their arrival in the White House.[14]

At Christmastime in 1808, Alexander Wilson arrived in the federal capital, on his way down the East Coast seeking subscriptions for the monumental work that elevated the study of American birds to a science. At the White House he presumably met Dick as well as Jefferson, who had already subscribed to *American Ornithology* and was no doubt instrumental in attracting seventeen subscribers in Washington, including three members of his Cabinet. An ardent Jeffersonian, Wilson had in 1805 sent the President a watercolor of two birds he had met near Niagara Falls and which he believed were new to science. Jefferson immediately consulted his volumes of Buffon and agreed that the jay had not previously been described. The other bird, however, was not only similar to a flycatcher he found illustrated in Buffon, but greatly resembled a small corpse that a local farmer had brought him to identify, "so putrid that it could not be approached but with disgust." Jefferson enlisted Wilson's aid in identifying a mystery bird that "perpetually serenades us with some of the sweetest notes, & as clear as those of the nightingale. I have followed it miles without ever but once getting a good view of it." After searching for a summer and conferring with William Bartram, Wilson concluded that it was the "wood robin" (Wood Thrush). He published Jefferson's query letter and the first image and description of the thrush in his *American Ornithology*. Jefferson evidently accepted this judgment, because in 1807 he recorded hearing the first notes of the "Incognito, or Wood Robin" on April 26.[15]

Wood Thrush, White-breasted Nuthatch, American Robin, and Red-breasted Nuthatch (Alexander Wilson, *American Ornithology*, volume 1, 1808).

Insects

Other than the house flies in the White House and notes of occasional ticks and fireflies at Monticello, the record of Jefferson's interest in insects relates mainly to economic pests. While serving in Philadelphia as Secretary of State in the spring of 1791, he urged his son-in-law in Virginia to take up the study of the grain

[14] WMB; Lucia Stanton, "Snowbirds and 'Superior Beings,'" *Fall Dinner at Monticello, November 4, 1988* (Charlottesville, 1988); Bear and Stanton, *Memorandum Books*, 2: 1101, 1112. Alexander Wilson wrote the words to "Jefferson and Liberty."

[15] Wilson to William Bartram, 4 March 1805, 2 July 1805; Wilson to Jefferson, 18 March 1805, 30 September 1805; Jefferson to Wilson, 7 April 1805, Clark Hunter, ed., *The Life and Letters of Alexander Wilson* (Philadelphia, 1983), 232, 233, 236-238, 244-246; WMB. Catesby's *Natural History* included only the Gray-cheeked Thrush. Neither the watercolor of the two Niagara birds, nor a second one Wilson sent to Jefferson of four of "our most capital Songsters" (Mockingbird, Brown Thrasher, Catbird, and Wood Thrush) have survived; the second was burned or lost in Louisiana during the Civil War.

weevil (*Sitophilus granarius*), then the principal enemy of their main cash crop, wheat. Jefferson also discussed the weevil with William Bartram, who believed it was the same pest that attacked plums, peaches, and apricots. Bartram promised "to shew me the insect this summer. — I long to be free for pursuits of this kind instead of the detestable ones in which I am now labouring without pleasure to myself, or profit to others."[16]

In mid-May, weary of the contentious climate in George Washington's cabinet, Jefferson left his desk to become a tourist, making a month-long journey with James Madison through upstate New York and New England. Even on vacation, Jefferson needed a public purpose. He was on the trail of the infamous Hessian fly (*Mayetiola destructor*), then working its way up and down the coast from its point of introduction on Long Island. He was chairman of a new committee of the American Philosophical Society, its mission to collect materials for "forming the Natural History" of the insect and finding "the best means of preventing or destroying" it." Jefferson filled six pages with notes on the fly's habits and depredations, based on interviews with farmers, tavern-keepers, and blacksmiths along his route. At the end of the journey, he and Madison reached the very spot (now part of Brooklyn) where American farmers had first watched their wheat stalks shrivel and break in 1777.[17]

Early in 1792, again "shut up drudging within four walls," Jefferson got to take a closer look at the enemy. He received some stalks of wheat containing pupae of the Hessian fly and, over the next two weeks, made detailed notes on the minute body parts of each adult fly, as it emerged from its "chrysalis." He watched one lay eggs and thought about the usual question, Was it a native or an immigrant? As he wrote his son-in-law, "the examination of a single one which hatched a week ago, gives me reason to suspect they are non-descript, and consequently aboriginal here." In the first years of its ravages, the insect was viewed as an alien, a stowaway in the straw for the Hessian troops that disembarked at Flatbush in 1776. George Morgan of Princeton claimed the honor of providing the sobriquet "Hessian." By linking the marauding gall midge to the German mercenaries, he believed he had furnished a "useful National Prejudice." Hessian flies reached Virginia during Jefferson's presidency. In 1817 he wrote from Monticello, "We, of this state, must ... be contented with so much [bread] as a miserable insect will leave us."[18]

Some of Jefferson's fellow Americans — his political opponents — were offended by the sight of a politician peering into the secrets of Nature. From the 1790s through his presidency, Federalist satirists had a heyday. In 1797, he was depicted "weighing the rats and mice of the two worlds to prove that those of the new are not exceeded by those of the Old." William Cobbett, in his fictitious will as Peter Porcupine, bequeathed to Jefferson "a curious Norway spider, with a hundred legs and nine pair of eyes." In 1804, another Federalist author imagined finding a fragment of Jefferson's diary on the banks of the Potomac. In it Jefferson cursed the irritating public business that interrupted his composition of a "dissertation on cockroaches." Three years later a youthful Washington Irving evoked a president who "amuses himself with impaling butterflies and pickling tadpoles."[19]

Plants

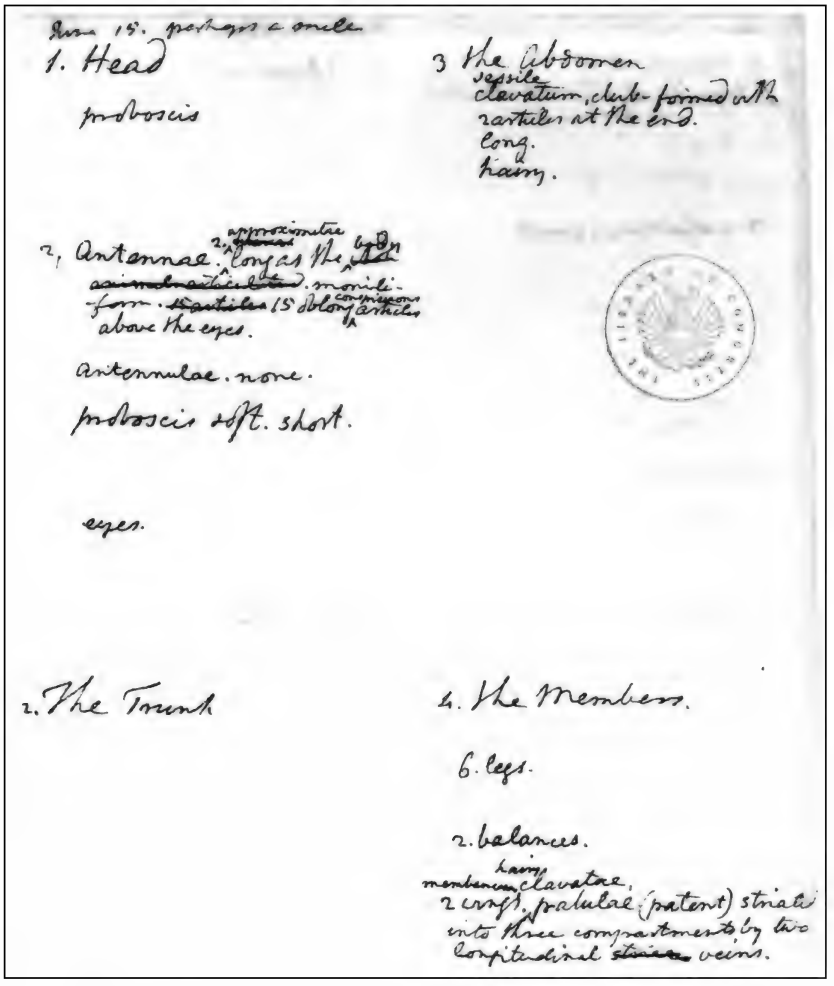
Jefferson was a passionate gardener and energetic proponent of botanical exchange, in accordance with one of his best-known sayings: "The greatest service which can be rendered any country is to add an useful plant to it's culture." In his five-year stint as minister to France, he acted on this belief by taking measures to introduce economic plants like upland rice and the olive tree to the southern United States. Ornamental plants were not neglected. Plant material crossed the Atlantic in both directions, as Jefferson gathered up European

[16] Jefferson to Thomas Mann Randolph, 1 May 1791, PTJ 20: 341. In fact, the "greater part" of Jefferson's 1791 wheat crop was lost to the weevil (Jefferson to James Lyle, 29 July 1792, PTJ 24: 266). See also Jefferson's Notes on Insects, 9 May 1798, PTJ 30: 340.

[17] American Philosophical Society Circular, 17 April 1792, PTJ 23:430, 432; Jefferson's Notes on Hessian Fly, [24 May-18 June 1791], PTJ 20: 456-461.

[18] Jefferson to Martha J. Randolph, 26 February 1792, PTJ 23: 159; Jefferson's Notes on Hessian Fly, [1-15 June 1792], PTJ 24: 11-14; Jefferson to Thomas Mann Randolph, PTJ 24: 83; George Morgan to Sir John Temple, 26 August 1788, Library of Congress: Jefferson Papers; Jefferson to William Johnson, 10 May 1817, Betts, *Garden Book*, 572. See also Brooke Hunter, "Creative Destruction: The Forgotten Legacy of the Hessian Fly," *The Economy of Early America: Historical Perspectives and New Directions*, ed. Cathy Matson (University Park, PA, 2006), 236-262, and Lucia C. Stanton, "Analyzing 'Atoms of Life'" (1991), http://www.monticello.org/site/house-and-gardens/hessian-fly.

[19] *Littell's Living Age* 87 (1865): 253; William Cobbett, *Porcupine's Works* (London, 1801), 5: 199; Harold Milton Ellis, *Joseph Dennie and His Circle* (Austin, 1915), 182; Linda K. Kerber, *Federalists in Dissent: Imagery and Ideology in Jeffersonian America* (Ithaca, 1980), 71.



Jefferson's notes on examining a Hessian fly (*Mayetiola destructor*) in June 1792 (Library of Congress: Jefferson Papers).

species for American gardens and badgered his friends back home to ship seeds of native trees and shrubs to Paris for avid gardeners there. One of the most eager collectors of American species was the Comtesse de Tessé, a relative of the Marquis de Lafayette. Jefferson struggled for years to fulfill her long wish-list, which included rarities like *Stewartia* and a plant that all his Parisian friends yearned to possess — the Venus flytrap (*Dionaea muscipula*).[20]

Jefferson welcomed and faithfully used what he called the "universal language" of the Linnaean binomial system. For a long time, however, he resisted attempts to modify it and, as late as 1814, described Jussieu's new natural system as a subject of "regret." Jefferson has been credited with the first scientific description of the pecan tree (*Carya illinoinensis*), published in his *Notes on Virginia* (Paris, 1785) a few months before Humphrey Marshall's *Arbustum Americanum* (Philadelphia, 1785). Writing in Paris, Jefferson began this last-minute addition to his *Notes*: "Were I to venture to describe this, speaking of the fruit from memory, and of the leaf from plants of two years growth, I should specify it as the Juglans alba, foliolis lanceolatis, acuminatis, serratis, tomentosis, fructu minore, ovato, compresso, vix insculpto, dulci, putamine, tenerrimo...."[21]

[20] Jefferson Summary of Public Service, after 2 September 1800, PTJ 32: 124; Betts, *Garden Book*, 117, 122, 131, 138-140, 149-150.

[21] Jefferson to John Manners, 22 February 1814, PTJ-R 7: 209-211; *Notes on Virginia*, 40; Rodney True, *Thomas Jefferson in Relation to Botany* (Lancaster, PA, 1916), 349-350. Jefferson left preparatory notes for a scientific description of sweet-shrub (*Calycanthus floridus*) among the loose memoranda related to *Notes on Virginia*, Massachusetts Historical Society: Jefferson Papers.

As a field botanist, a twenty-three-year-old Jefferson made a shaky start in the spring of 1766. On the first page of his best known book of record, his Garden Book, he made brief notes of the succession of blooming wildflowers along the banks of the Rivanna River — bloodroot (*Sanguinaria canadensis*), Virginia bluebells (*Mertensia virginica*), wild iris (*Iris virginica*), and wild azalea (*Rhododendron periclymenoides*): "Puckoon open" (April 6); "Puckoon flowers fallen" (April 13); "a bluish colored, funnel-formed flower in lowgrounds in bloom" (April 16); "purple flag blooms" (April 30); "Wild honeysuckle in our woods open" (May 4). A week later he wrote, "Went journey to Maryland, Pennsylva., New York. so observations cease." And they ceased forever. These were Jefferson's first and last recorded notations on his native flora in any systematic way. He saved his methodical recordkeeping for his vegetables.[22]

In 1778, Jefferson confessed that he was "acquainted with nothing more than the first principles" of botany. Although he never became a scientific botanist, he always remained a plant lover. In 1791, on the northeastern journey with James Madison, new botanical objects provided the greatest enjoyment of the trip. After his return to Philadelphia, Jefferson made an effort to identify the unfamiliar trees and shrubs they had seen by consulting his memory and the short descriptive epithets he had written in his journal of the tour. As he wrote to Madison: "I am sorry we did not bring with us some leaves of the different plants which struck our attention, as it is the leaf which principally decides specific differences." He was baffled by the identity of a fragrant azalea he saw in the Hudson Valley and described as "wild honeysuckle rose-coloured, on stems 4. f. high loaded richly with large flowers of a strong, pink fragrance." He doubted that it was the familiar wild azalea (now *Rhododendron periclymenoides*), but could not find the species in any books in his library. In fact, it took botanists another century to decide on a name for what was probably *R. prinophyllum*.[23] President Jefferson's plant-focused escapes from the White House a decade later were described by his friend Margaret Bayard Smith:

> When he took his daily ride, it was always on horseback and alone. It was then he enjoyed solitude, surrounded only by the works of nature of which he was a fond lover and great admirer. He used to explore the most lonely paths, the wildest scenes among the hills and woods of the surrounding country, and along the high and wooded banks of the Potomac. He was passionately fond of botany, not a plant from the lowliest weed to the loftiest tree escaped his notice, dismounting from his horse he would climb rocks, or wade through swamps to obtain any plant he discovered or desired.[24]

Since Jefferson never went south of Norfolk or west of Hot Springs, his botanizing in the nation at large was mostly vicarious. He knew the leading nurserymen and plant collectors and influenced the travels of some of the latter. He tried to divert André Michaux from a collecting trip by tapping him to lead a transcontinental exploring expedition. Political developments derailed this plan and the Frenchman continued on his intended route southward. For Michaux, Virginia was always more of a way station than a destination, as he usually made a beeline to the highest peaks of the Appalachians or the Carolina low country. He did, however, make a stop to botanize in the Blue Ridge in Wythe County in 1789, where he collected the plant that became Jefferson's botanical namesake. Michaux dug the roots of twinleaf (*Jeffersonia diphylla*) on July 4, and carried them back to William Bartram's garden in Philadelphia. Almost two years later, Bartram and Benjamin Smith Barton observed the plant in bloom. They jointly made the first drawing of a flowering twinleaf and realized that it was not a *Podophyllum*, as Linnaeus had classified it. In 1792, Dr. Barton announced to the American Philosophical Society that he gave it the name *Jeffersonia binata* in honor of the man whose knowledge of natural history, "especially in botany and in zoology ... is equalled by that of few persons in the United-States."[25]

While most of the plant collectors of Jefferson's time passed quickly through the Shenandoah Valley enroute to the Carolina mountains and Coastal Plain, Jefferson succeeded in persuading some of them to linger a bit longer in Virginia. He had first met Scottish linen draper turned plant hunter John Fraser in Paris in the 1780s. A skillful marketer, Fraser promoted a fairly common American bent grass (*Agrostis perennans*) as a

[22] Betts, *Garden Book*, 1.

[23] Jefferson to Giovanni Fabbroni, 8 June 1778, PTJ 2: 196; Jefferson to James Madison, 21 June 1791, PTJ 20: 560; Jefferson Journal of a Tour, [21 May-10 June 1791], 20: 453.

[24] Smith, *Washington Society*, 393.

[25] C. S. Sargent, "Portions of the Journal of André Michaux," *Proceedings of the American Philosophical Society* 26 (1889): 55, 136; [Benjamin Smith Barton,] "A Botanical description of the *Podophyllum diphyllum* of Linnaeus," *Transactions of the American Philosophical Society* 3 (1793): 337-338, 342. See also Lucia Stanton, "Jefferson's Namesake" (1992), http://www.monticello.org/site/house-and-gardens/twinleaf.

Jeffersonia diphylla, engraved from a drawing by William Bartram and Benjamin Smith Barton of a plant collected by André Michaux in 1789 (*Transactions of the American Philosophical Society*, vol. 3, 1793).

forage plant of extraordinary value. He sold to Jefferson (and a long list of aristocrats that included the Marquis de Lafayette) a quart of the seed for the equivalent today of three hundred dollars.[26]

In 1800, on one of several collecting trips to the United States, Fraser and his son spent two summer days at Monticello. They enjoyed the views as well as the hospitality and conversation of their host. John Fraser, Jr., wrote that "Mr. Jefferson possesses a most comprehensive genius; he seems to be acquainted with the theory of every science, and is quite an adept at mechanism. He tells us he has given up paying attention to *Botany*, of which he was once so fond; his public duty, and the intricacies of politics, requiring all his time." The Frasers had been planning to visit Washington, DC, but Jefferson, then Vice President, told them that the federal capital was "not worth the trouble." They should instead cross the Blue Ridge Mountains to see the Natural Bridge in Rockbridge County. Jefferson urged every foreign traveler who stopped at Monticello to see the natural wonder that he had owned since 1774. The Frasers journeyed from Monticello to the Natural Bridge, on to White Sulphur Springs, and back to Botetourt County, from where young John Fraser wrote of their eight-hundred-mile tour from their base in South Carolina, "We have hitherto travelled thro' a country very destitute of botanical subjects."[27]

In 1802, Jefferson's great white hope arrived at Monticello. Determined that native-born Americans should be the discoverers and describers of America's flora and fauna, he put his faith in Benjamin Smith Barton to lead the American scientific team to eminence. When Dr. Barton was working on his flora of Virginia, he needed to return Henry Ernest Muhlenberg's copy of C. H. Persoon's *Synopsis Plantarum* and asked to borrow Jefferson's, with the comment: "I know of no other copy in the country, that at Monticello excepted."[28] Jefferson welcomed the first American botanical textbook, Barton's *Elements of Botany* (1803), and recommended it widely, but he so lamented the absence of an index that he spent hours making one himself. In 1813, Jefferson asked Barton, "When shall we have your book on American botany, and when the 1st volume of Lewis & Clarke's travels?" But the learned doctor died in 1815, leaving much of his work incomplete.[29]

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[26] David H. Rembert, "Thomas Walter Carolina Botanist," *South Carolina Museum Bulletin*, no. 5 (1980), 18-19; John Fraser, *A Short History of the Agrostis Cornucopiae; or, the new American Grass* (London, 1789).

[27] John Fraser, Jr., to unidentified recipient, 1800 (Charleston *City-Gazette and Daily Advertiser*, 17 October 1800).

[28] Benjamin Smith Barton to Jefferson, 16 October 1810; Jefferson to Barton, 22 October 1810, PTJ-R 3: 167, 181. When Jefferson sold his library to Congress in 1815, he requested the return of the volumes (Jefferson to Barton, 26 February 1815, Barton to Jefferson, 6 March 1815, PTJ-R 8: 284, 319).

[29] Joseph Ewan and Nesta Dunn Ewan, *Benjamin Smith Barton: Naturalist and Physician in Jeffersonian America* (St. Louis, 2007), 413; Jack McLaughlin, "The Organized President," *American Heritage* 42 (1991), 86-89; Jefferson to Benjamin Smith Barton, 3 April 1813, PTJ-R 6: 46.

Barton's notes on his rambles through Virginia are a fascinating compendium of information about the names, uses, and origins of plants, gleaned from conversations with Virginians he encountered as well as his own observations. He learned how to cure gout and rheumatism with tulip poplar leaves, how to save the lives of turkeys who had ingested Jimsonweed, how to mend china with puttyroot, and he described the use of dried pods of unicorn plants (*Proboscidea louisianica*) as coat hangers. As he neared Monticello on a late August afternoon he noted pawpaw (*Asimina triloba*), horsemint (*Monarda punctata*), "and some Ricinus communis [castor bean], which, however, is hardly indigenous in this spot." Then Barton turned into, from the perspective of those of us who thirst for details of Jefferson's mountain home, one of most disappointing of all visitors to Monticello. After writing that he arrived on the mountaintop about two o'clock, he penned a title for the page ("Monticello") with a flourish and began, "Monticello is the beautiful seat of Mr. Jefferson." The rest of the page is blank, awaiting impressions that Barton never got around to transcribing. On other pages in his notes he revealed that he talked to Jefferson about fireflies, hummingbirds, strawberry-bush (*Euonymus americanus*), umbrella magnolia (*Magnolia tripetala*), and honey locust (*Gleditsia triacanthos*). Jefferson informed his guest that insects, and therefore insect-eating birds like swallows, were rare on the mountaintop. According to Barton, Jefferson "cannot prevail upon the martins (Hirundo purpurea) to stay, but the Chimney-birds (Hirundo Pelasgia) do."[30]

Although there is no record of a visit to Monticello, Jefferson no doubt met John Lyon, who made ten journeys to collect American plants for his London nursery; one of his auction sales was reckoned to include "the greatest collection of American trees and shrubs ever brought to England at one time, by one individual." Lyon is said to have been the last person to have seen *Franklinia alatamaha* in the wild. His botanical journal provides a record of his observations as he hurried through Virginia on his way to richer pastures. At Harper's Ferry in May 1804 he gathered two hundred roots of *Jeffersonia*. In 1807, traveling through Richmond and Petersburg, he was struck by meeting a number of southern plants at their northern limits. A year later he made a two-day detour from the Valley road to view the Natural Bridge and climb the Peaks of Otter, "from which is a most extensive and varied view." There he "observed a number of uncommon plants," among them Catawba rhododendron (*Rhododendron catawbiense*), Michaux's saxifrage (*Hydatica petiolaris*), and one of the more than thirty American plants he first introduced to England, bleeding heart (*Dicentra eximia*).[31]

Another English botanist paid Jefferson a visit in August 1809. John Bradbury, seeking new and unusual plants for the Liverpool Botanic Garden, headed directly to Monticello soon after his arrival in the United States. He spent almost two weeks there and, according to his host, passed "every day in the woods from morning to night. he found, even on this mountain, many inedited articles."[32] Bradbury reported to his sponsors in Liverpool that he had found at Monticello a number of new ladyslippers and "Heleborines," plus "two new Cacaliae a new & most Odorous Coreopsis a new Talinum a beautiful Rock Plant and many others of which I am doubtful." He also noted that he had "the advantage of a very good Botanic Library," where, among other works, he consulted Jefferson's Persoon. The evenings were evidently filled with discussions of the discoveries in natural history of the Lewis and Clark expedition. Bradbury reported that Jefferson wished to send to Liverpool seeds of a fast-ripening maize — a variety grown by the Mandan tribe in present North Dakota that Jefferson thought would be "an Immense acquisition to Britain."[33]

Many of the "inedited" plants Bradbury found at Monticello defy certain identification today. Some were removed to Jefferson's garden and others were marked in the woods, to await arrangements for transport to Liverpool. Bradbury apparently never reclaimed them. On Jefferson's advice, he abandoned his plans to make the already well-combed region from Kentucky to New Orleans the center of his operations. Not content "with gleaning when by a little more exertion I may become a first Reaper," he proceeded instead to St. Louis and

[30] W. L. McAtee, ed., "Journal of Benjamin Smith Barton on a Visit to Virginia, 1802," *Castanea* 3 (1938), 86-117; Barton's additional manuscript notes of his 1802 journey, American Philosophical Society: Barton Papers, 8: 32-40. These notes were kindly shared by the late Joseph Ewan in 1980.

[31] J. C. Loudon, *Arboretum et Fruticetum Britannicum* (London, 1838) 1: 122; Joseph and Nesta Ewan, "John Lyon, Nurseryman and Plant Hunter, and His Journal 1799-1814," *Transactions of the American Philosophical Society*, n. s., 53 (1963): 5-12, 22-23, 26, 32, 37.

[32] Jefferson to Benjamin Smith Barton, 11 September 1811, PTJ-R 4: 147.

[33] John Bradbury to William Roscoe, 12 August 1809, PTJ-R 1: 436-437; Bradbury to James Edward Smith, Linnean Society, London: Smith Manuscripts; partially printed in PTJ-R 1: 437.

eventually up the Missouri River, the first botanist to follow in the steps of Lewis and Clark. Unfortunately, Bradbury did not reap any rewards for his harvest of botanical novelties. Many of his new American species were described and published by Frederick Pursh in his *Flora Americae septentrionalis* (1814), "depriving me," as Bradbury bitterly wrote, "both of the credit and profit of what was justly due to me." His herbarium specimens had a checkered career and, at one point, were found being used by the gardeners at the Liverpool Botanic Garden as spills for their tobacco pipes.[34]

By the time of Bradbury's visit, Jefferson had finally retired to Monticello, where botany was "but an object of amusement, a great one indeed and in which all our family mingles more or less." And soon another European botanist became a regular participant in the household's botanical amusements. José Corrêa da Serra, a Portuguese abbot known for his universal learning and epigrammatic wit, first arrived at the mountain in the summer of 1813. Jefferson was captivated by the worldly abbé, calling him "the greatest collection, and best digest of science in books, men, and things that I have ever met with." A mutual friend reported that Corrêa "was enchanted with Monticello and delighted with its owner." He made what he called his "annual pilgrimage to the Holy Land" six more times before returning to Europe in 1820.[35]

Corrêa's curiosity about American natural history caused him to travel north to the Canadian border, west to Kentucky, and south to Georgia. He was particularly drawn to the Dismal Swamp and its environs, which he noted as "the point of contact of the southern and northern systems of vegetation of the United States." The abbé, who incorporated Jussieu's classification method into the botany classes he taught in Philadelphia, finally convinced Jefferson to relent in his opposition to the new natural system. He advised Jefferson on a botanical curriculum and prepared a plan for a botanic garden for the University of Virginia. In the last weeks of his life, Jefferson selected a site for the six-acre garden, which was to be "restrained altogether to objects of use, and indulging not at all in things of mere curiosity." Despite his strong support for its immediate construction, the botanic garden was never built.[36]

In September 1815, Corrêa and the young Virginian Francis Walker Gilmer stopped to visit Jefferson at his Bedford County retreat, Poplar Forest, before making a tour of the Deep South. The three men headed into the Blue Ridge, where the seventy-two-year-old Jefferson and his friends passed two days "taking the elevation of the Peaks of Otter and then exploring the sides of them for subjects botanical."[37] They traveled farther west to view the Natural Bridge and then parted, saying their farewells actually "on" the bridge. Corrêa and Gilmer turned south while Jefferson went back to Poplar Forest and wrote to the governor of Georgia. He introduced the two travelers and noted that, "as every plant of any singularity stays them, their progress will be slow."[38]

While Corrêa and Gilmer made their long journey, Jefferson returned to the Blue Ridge for further measurements and spent five days making geometrical computations to determine the elevation of the Peaks of Otter.[39] Such astronomical and mathematical exercises, rather than biological observations, were the favorite pastime of his retirement. Jefferson had, however, another botanical role to play. In 1821, he was offered a manuscript written by the late Dr. James Greenway of Dinwiddie County, the only known flora of the state between John Clayton and J. F. Gronovius' *Flora Virginica* (1739-1743; 2nd edition 1762) and the

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[34] John Bradbury to William Roscoe, 12 August 1809; Bradbury, *Travels in the Interior of America, in the Years 1809, 1810 and 1811* (London, 1817), 79.

[35] Jefferson to Benjamin Smith Barton, 22 October 1810, PTJ-R 3: 181; Jefferson to Caspar Wistar, 17 August 1813, PTJ-R 6: 415; William Short to Jefferson, 18 January 1814, PTJ-R 7: 139; Corrêa to Francis W. Gilmer, 30 April 1818, Richard Beale Davis, *The Abbé Correa in America, 1812-1820* (Providence, 1993), 237.

[36] Corrêa to Francis W. Gilmer, 30 April 1818, Davis, *The Abbé Correa*, 238-239; Lily Fox-Bruguiere, "An Uncultivated Legacy: Jefferson's Botanical Garden at the University of Virginia," M.A. thesis, University of Virginia, 2010.

[37] Peachy Gilmer to Francis W. Gilmer, 3 October 1815, Richard Beale Davis, *Francis Walker Gilmer: Life and Learning in Jefferson's Virginia* (Richmond, 1939), 90. In the 1780s, Jefferson had supposed that the Peaks of Otter were the highest mountains in Virginia and perhaps all of North America, "measured from their base" (*Notes on Virginia*, 22, 293).

[38] Jefferson to Corrêa, 1 January 1816, PTJ-R 9: 308; Jefferson to John Milledge, 22 September 1815, PTJ-R 9: 38-39. A souvenir of their trip survives in the library of the University of Virginia, a copy of André Michaux's *Flora Boreali-Americana* given to Gilmer by Charleston physician and botanist James McBride. It contains marginalia about plant uses and common names by both Gilmer and McBride.

[39] For Jefferson's field notes and calculations, see PTJ-R 9: 153-174 and *Notes on Virginia*, 293.

monumental manual published last year.[40] Jefferson would probably have sympathized with Greenway's regret that Clayton, by sending his dried Virginia plants to Holland for publication, had "deprived his Country of the Honour" of describing and publishing them. In accepting Greenway's manuscript, Jefferson said that he wanted to honor its author and "give benefit to the world." He had it bound in Richmond and placed with books destined for the University of Virginia, then under construction. He told Greenway's son that he had looked over the flora "with sufficient attention to satisfy myself of it's merit and that it's matter should not be lost to the world." But it was lost. Greenway's manuscript, lying unpublished in the University's Rotunda library for the rest of the century, was apparently burned in the fire of 1895.[41]

Although Jefferson was never a full-fledged practicing naturalist, he unquestionably contributed to the expansion of knowledge of his nation's natural history, especially as sponsor of the Lewis and Clark expedition, which yielded several hundred plants and animals new to science. Jefferson's own knowledge is reflected in his choice of its leader. Although he was subsequently criticized for not assigning a trained naturalist to the Corps of Discovery, Jefferson knew that Meriwether Lewis had a "talent for observation, which had led him to an accurate knoledge of the plants & animals of his own country." Lewis could thus distinguish new from known species, accurately recalling the precise color of the speckles of the Brook Trout and number of feathers in the tail of the Ruffed Grouse. Jefferson's instructions to his fellow Virginian, besides enjoining attention to new or rare animals and "vegetable productions" along the route, were to make careful observations of the climate and, of course, "the dates at which particular plants put forth or lose their flower, or leaf, times of appearance of particular birds, reptiles or insects." It is fitting that Jefferson seems to have taken up his pen for the very last time after consulting his rain gauge. He made this final notation in his weather diary five days before his death on July 4, 1826: "r = 0.95."[42]

[40] Alan S. Weakley, J. Christopher Ludwig, and John F. Townsend, *Flora of Virginia* (Fort Worth, 2012).

[41] Jefferson to Robert Bolling Stark, 7 October 1818, Huntington Library, San Marino, CA; Jefferson to Robert Greenway, 17 April 1821, 12 December 1822, Library of Congress; James Greenway to Benjamin Smith Barton, 17 October 1791, Ewan and Ewan, *Benjamin Smith Barton*, 595.

[42] Jefferson to Paul Allen, 18 August 1813, PTJ-R 6: 419; Paul Russell Cutright, *Lewis and Clark: Pioneering Naturalists* (Lincoln, NE, 1989), 15, 397-398; Jefferson to Meriwether Lewis, 20 June 1803, Donald Jackson, ed., *Letters of the Lewis and Clark Expedition* (Urbana, 1978), 63; WMB, 29 June 1826. Jefferson's last known letter was to George P. Stevenson, 25 June 1826 (J. Jefferson Looney, "Thomas Jefferson's Last Letter," *Virginia Magazine of History and Biography* 112 [2004]: 179-184).

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The History of Mammal Studies in Virginia

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ABSTRACT

Native mammals surely were among the first biota to be observed, admired, and described by the earliest European colonists to Virginia. It was natural for them to make comparisons with British mammals, such as deer, elk, and squirrels. More puzzling to colonists were mammals with no counterparts in England, such as raccoons (thought by John Clayton to be a kind of monkey) and especially the Virginia opossum, a pouched mammal. Perhaps the best early record of the mammal fauna of Virginia is from William Byrd's 1728 account of his group's journey while surveying the 'dividing line' between Virginia and North Carolina. Byrd later published his extensive notes on the mammals observed and eaten by the group: black bears, white-tailed deer, elk, and American bison (buffalo), as well as Virginia opossum, raccoon, and otter. The first scientific studies of Virginia mammals were conducted during 1895-1898, when field investigators from the US Bureau of Biological Survey and three museums spent a total of 23 weeks collecting mammals in the Great Dismal Swamp of southeastern Virginia. During the first half of the 20th century, a number of collectors made contributions to understanding the distribution of mammals in Virginia, but the major advances have been in recent decades by investigators in association with universities in Blacksburg, Richmond, and Norfolk, among others. Much remains to be learned about the distribution and status of Virginia mammals before a definitive work on mammals of the Commonwealth can be written.

Key words: history, mammalogy, mammal collections, people, Virginia mammals.

The discovery of the Americas and their early exploration and settlement were dominated by Spain, Portugal, and France (Horowitz, 2008). Nearly 100 years after Columbus's voyage, Sir Walter Raleigh's 1585 visit to the East Coast led to rapid interest in establishing English colonies in America for political and economic reasons. The first English settlers to eastern Virginia found mammals in great abundance, including many similar to those of their home country; early accounts often compared local mammals with those from England. Mammals of greatest interest and curiosity, such as raccoon, opossum, and American bison[1], were those lacking counterparts in England or western Europe. Later accounts described behavior or anatomy as writers began to think of native mammals as American rather than merely different from English mammals. By the time of the American Revolution, writers had taken ownership of our mammals and rebutted charges that American mammals were fewer, smaller, and degenerate compared to those from England or Europe.

The first reports in English on the mammals of Virginia (Table 1) were those of Thomas Hariot, one of the founders of the Roanoke Island Lost Colony. At that time (1588), Virginia extended south to what is presently Florida. Hariot writes of (white-tailed) deer, "by the thousands," and of having seen the furs of (river) otters, of which he saw many, and of martens (he saw only two skins). [Note: what he calls martens likely were mink rather than pine martens; the latter, also members of the weasel family, Mustelidae, probably were then, as now, restricted to the montane or cool habitats of Appalachia and points north.] Hariot reports having seen a "civet cat" (bobcat) that had been "killed by a savage, and bears, which are black in color." He explains that black bears are good meat and are hunted by chasing the bear up a tree and then shooting it with bows and arrows." Conies "that

[1]Common names are used throughout the text. For companion scientific names, see Table 1.

Table 1. Common and scientific names of the mammals reported by early observers of mammalian wildlife in Virginia, listed phylogenetically and with common names according to Wilson & Ruff (1999). The year of discovery or first mention of each species is listed, which is not always the publication year.

Opossum, *Didelphis virginiana,* Smith, 1608
Little brown bat, *Myotis lucifugus,* Clayton, 1686
Big brown bat, *Eptesicus fuscus,* Clayton, 1686
Rafinesque's big-eared bat, *Corynorhinus rafinesquii,* Clayton, 1686
Gray wolf, *Canis lupus,* Hariot, 1588
Common gray fox, *Urocyon cinereoargenteus,* Clayton, 1686
American black bear, *Ursus americanus,* Hariot, 1588
American marten, *Martes americana,* Hariot, 1588
Long-tailed weasel, *Mustela frenata,* Hariot, 1588
Mink, *Mustela vison,* Smith, 1608
Northern river otter, *Lontra canadensis,* Hariot, 1588
Striped skunk, *Mephitis mephitis,* Smith, 1608
Northern raccoon, *Procyon lotor,* Smith, 1608
Cougar, *Puma concolor,* Hariot, 1588
Bobcat, *Lynx rufus,* Hariot, 1588
Elk, *Cervus elaphus,* Byrd, 1728
White-tailed deer, *Odocoileus virginianus,* Hariot, 1588
American bison, *Bison bison,* Byrd, 1728
Eastern chipmunk, *Tamias striatus,* Byrd, 1728
Eastern gray squirrel, *Sciurus carolinensis,* Smith, 1608
Eastern fox squirrel, *Sciurus niger,* Smith, 1608
Southern flying squirrel, *Glaucomys volans*, Smith, 1608
American beaver, *Castor canadensis,* Smith, 1608
Allegheny woodrat, *Neotoma magister,* Cope, 1868
Muskrat, *Ondatra zibethicus,* Smith, 1608
Eastern cottontail, *Sylvilagus floridanus,* Hariot, 1588
Marsh rabbit, *Sylvilagus palustris,* Hariot, 1588

we have seen ... are of a grey colour like unto our hares." "Coney" is a British term for rabbit; Hariot likely is referring to marsh rabbits or eastern cottontails, both of which are present along the mid-Atlantic coast. Hariot ate "Saquenuckot & Maquowoc, two kinds of small beasts greater than Conies, which are very good meat." My guess is that these were opossums and raccoons, or, less likely, beavers. Finally, he says that the "inhabitants sometimes kill the lion (cougar) and eat him, and we sometimes as they came to our hands, of their wolves or wolfish dogs, which I have not set down for good meat." Clearly, cougars and wolves were known to the founding colony on Roanoke Island.

John Smith, who became the leader of the founding party at Jamestown Island after 1607, spent a year investigating the lower Chesapeake Bay and later wrote descriptions of the animals he had seen (Tyler, 1907). Regarding squirrels, most are gray, he says, but some are black and white; here he is referring to the coastal subspecies of the fox squirrel, which is blackish gray with a black face and white snout. Smith also describes a "small beast they call Assapanick, but "we call them flying squirrels because they spread their legs, and so stretching the largeness of their skins, that they have been seene to fly 30 or 40 yards." These would have been southern flying squirrels, a 70-g tree squirrel that glides from tree to tree using its well-furred membranes that connect the limbs on each side of the body. His description of an opossum is particularly interesting: "hath a head like a Swine, and a taile like a Rat, and is of the bigness of a cat. Under her belly she hath a bagge, wherein she lodgeth, carrieth, and sucketh her young." The pouch of the Virginia opossum fascinated a number of English observers because they had nothing like it in their experience. Marsupials, except the Virginia opossum, presently are restricted to South America and to the Australasian region.

Smith (Tyler, 1907) also describes the Mussacuscus (muskrat) as a "beast of the forme and nature of our Water Rats, but many of them smell exceeding strongly of muske." The beaver, he reports, is "big as an ordinary water dogge, but his legs exceedingly short. His fore feet like a dogs, his hinder feet like a Swans. His taile somewhat like the form of a Racket bare without hair, which to eat, the Savages esteeme a great delicate." Both semi-aquatic rodents would have been common along the waterways and associated marshes of coastal Virginia. Another mammal Smith observed was "a beast they call Aroughcun, much like a badger, but useth to live on trees as squirrels doe." Our modern term 'raccoon' seems to have been derived from its Native American name. Other early English observers refer to the raccoon as a type of monkey, with its masked face and banded tail. As a member of the New World family Procyonidae, the raccoon was totally foreign to the experience of English observers.

Smith relates "there also is a beast they call Vetchunquoyes in the form of a wild Cat." This would be the bobcat, the only small cat in the eastern US. He also mentions seeing "martins, powlecats, weasels, and minkes" as skins, though seldom alive. Polecat refers to a member of the weasel family that in Europe gave rise to the domesticated ferret. In modern America, the term "polecat" now refers to the striped skunk (which probably was present in the newly created Jamestown settlement) and the spotted skunk (now rare and restricted to western Virginia). Early drawings of the polecat looked much like the striped skunk, so the English name for a smelly weasel was applied to our skunk of eastern Virginia.

John Banister provides a number of interesting observations of mammals in his writings made during the late 17th century (Ewan & Ewan, 1970). For example, in 1686, Banister hosted the Rev. John Clayton, the premier botanist of the era, to whom he exhibited the backbone of a whale. Like Clayton, Banister was a minister and also shared his interest in collecting plants. In 1690, Banister was one of the founders and first Trustees of the College of William and Mary. Two years later he was accidentally shot and

killed while botanizing along the Roanoke River (Ewan & Ewan, 1970). Among Banister's writings were good descriptions of the beaver lodge, how dams are built, and of castoreum, the "stinking oyle of beavers stones" (their castor glands). Banister says that the native deer has "flesh as sweet as mutton," there were three kinds of squirrels (fox, gray, and flying), and that the opossum was "a sort of creature with a false belly, which receives its young when in danger and it hangs by its taile." He mentions that muskrats eat mussels and defecate pearls (nice trick) and then describes their musk glands. Banister also made the observation that American (gray) foxes live in trees, whereas English (red) foxes nest in holes in the ground. It seems that Banister was an excellent artist because much later the Swedish botanist, Carl von Linne, used at least 64 of his drawings and referenced 127 of his plants in the 1753 publication of *Species Plantarum*, the first volume in which Linnaeus made detailed anatomical plant descriptions in Latin and introduced the binomial system of nomenclature, still in use today.

John Clayton spent only two years (1686-1688) in America, during which time he was rector of an Anglican parish in James City, Virginia (Berkeley & Berkeley, 1965). An accomplished scientist and member of the Royal Society before coming to America, Clayton returned to England and spent the remaining 40 years of his life relating his impressions of the biota and environments of Virginia. In this way, he contributed greatly to English perceptions of what Virginia and America were like. Like Banister, Clayton also noticed that gray foxes did not use ground holes ("but of this I am not positive"). In this regard, he was a careful scientist, by not giving his hunch the certainty of a statement based on observation. Clayton mentions having heard about elk(e) but they were present 'beyond the habitations', i.e., farther west from his location or travels. "Brave red Deare" were common "so that a good woodsman, as they call them, will keep a house with Venison."

Clayton said that the "Rackoone I take it to be a species of monkie, something less than a fox, gray haired, its feet formed like a hand, and the face too has likewise the resemblance of a monkies, besides being kept tame, they are very Apish, they are very prejudicial to their poultry, as I remember" (Clayton, 1694). Of the opossum, he said the "Skin of its belly is very large and folded so as to meet like a purse, wherein they secure their young whilst little, and tender, in this false bellys they will carry their young." Clayton gives detailed descriptions of three kinds of squirrels and of rabbits. Of the latter he relates that "I have seen Leverets (young rabbits or hares), there with the white spot in the head, which the old ones have not, so it is in England; and the downe is perfectly the colour of their hairs, they sit as our haires doe." Thus, he notes that young rabbits in America, as in England, have white spots on their heads which later disappear in adults and that their behaviors are similar. Clayton's observation suggests a degree of relatedness of rabbits in both America and England not mentioned by other early naturalists. Clayton saw two kinds of bats, one with "long eares, and particularly long straggling hairs;" this likely was Rafinesque's big-eared bat, now the State bat of Virginia. The other bat was "much like the English, something larger I think, very common." This probably was either big brown bat or, less likely, little brown myotis, both common bats in the region.

Clayton gives detailed descriptions of the structures built by muskrats and beavers but he erred by saying of muskrats "I suppose they live mostly on fish," and in believing the value of beaver lodges was "As I suppose ... to catch fish by standing to watch them thereon, and jumping upon them on a sudden (movement?)." He tore apart a muskrat house to find "4 different Lodgeing rooms, very neat, one higher than the other, as I conceive purposely made for retirement, when the Water rises higher than ordinary." Regarding the beaver's industry in building dams and lodges, Clayton wrote "They are very subtle Creatures and if halfe of the stories be true that I have been told they have a very orderly government amongst them, in their works each knows his proper work, and station, and the overseers beat those young ones that loiter in their business, and will make them crie, and work stoutly." Finally, Clayton saw a young bear but his remarks on other carnivores (cougars, wolves or coyotes, cats or polecats) are all second-hand reports; perhaps by the end of the 17th century most carnivores were uncommon in eastern Virginia.

An early 18th century account by Robert Beverley (1705) indicates an abundance of "Deer, Hairs, Foxes, Raccoons, Squirrels, Possums. And upon the Frontier Plantations, they meet with Bears, Panthers, Wild-Cats, Elks, Buffaloes, and Wild Hogs, which yield Pleasure, as well as Profit to the Sports-man." Beverley's only detailed information is on the Virginia opossum. After describing the pouch of females, he says "But, what is yet stranger, the young Ones are bred in this false Belly, without ever being within the true One (i.e., the *uterus*). They are formed at the Teat, and there they grow for several Weeks together into perfect Shape, becoming visibly larger ... I have observed them thus fasten'd at the Teat, from the Bigness of a Flie, until they became as large as a Mouse." Of course, later study revealed that opossums have a brief gestation in a bona fide uterus, after which the young, born in a

primitive state, crawl unaided into the pouch, attach to a teat, and complete their development there while being nourished by milk.

Perhaps the best accounts from the early period were those of William Byrd II of Westover, Beverley's brother-in-law. His father was a prominent landowner and official who died in 1704, causing the younger Byrd to return (at age 30) from England to assume his father's public and private duties (Bassett, 1901). Byrd II was educated in England, where he was elected a member of the Royal Society of London, despite having given only one paper to that organization. At the time of his death in 1744, his library, at 4,000 books, was probably the largest in the colonies, so besides being well educated he was also well read. Despite being 54 years old in 1728, Byrd was appointed as one of the Virginia Commissioners to oversee surveying the dividing line 'betwixt' Virginia and North Carolina.

On 6 March 1728, the group drove a cedar post in the sand at 36° 30′ N at the south end of Currituck Inlet and began moving westward towards the Dismal Swamp. After the survey party crossed the Roanoke River, their Indian scout shot the first black bear. Byrd wrote that many woodsmen preferred bear meat to venison because "its flesh is very firm and may be eaten plentifully without rising in the stomach." Further, "the Paw ... is accounted a delicious morsel by all who are not shocked at the ungracious resemblance it bears to a human foot." Later, one of his group shot a wild-cat (bobcat), "which was at the fatal moment making a comfortable meal upon a fox-squirrel ... The flesh of this beast, as well as of the panther (cougar or mountain lion), is as white as veal, and altogether as sweet and delicious." Having eaten cougar meat at a mammal society banquet, I agree.

The Indian scout and others routinely brought white-tailed deer and turkeys every day to supplement their ration of 5 pounds of hardtack per man per week. Byrd often discusses the plants the group observed, such as rattlesnake root, a plant with supposed benefits to treat snakebite, and Colt's foot and maidenhair (fern), "both excellent pectoral plants." He also gives details of the life cycle and behaviors of bears, beavers, raccoons, and other mammals. In a remarkable insight, Byrd notes that Indians have not domesticated any animals except dogs. He does know, however, that South American natives had domesticated an animal he calls the "paco," which we know to be either guanaco or llama.

On October 24, one of the hunters shot a raccoon; "the fat of this animal is reckoned very good to assuage swellings and inflammations." "It climbs up small trees, like a bear, by embracing the bodies of them." He also reports having seen four kinds of squirrels: fox, gray, flying, and "the ground-squirrel. These last ... have ... black and russet streaks that run down the length of their little bodies." These would be eastern chipmunks, the common ground squirrel of eastern forests. On October 26, after one of the men had picked up a pair of elk antlers, Byrd remarks that elk "keep commonly to the northward of 37 degrees, as the buffaloes, for the most part, confine themselves to the southward of that latitude." Then Byrd discusses at length the biology of elk, including size, sex differences, quality of their flesh, their shy behavior, good sense of smell, herding behavior, and other traits. Byrd's breadth and depth of knowledge on a wide range of subjects is remarkable.

One hunter brought in an opossum on October 30, "a harmless little beast ... if you take hold of it, it will only grin, and hardly ever bite. The flesh is well tasted and tender, approaching nearest to pig ..." Then Byrd describes its features, including differences between its front and hind feet, and especially the pouch of females. "Within this false belly may be seen seven or eight teats, on which the young ones grow from their first formation till they are big enough to fall off, like ripe fruit from a tree. This is so odd a method of regeneration, that I should not have believed it without the testimony of mine own eyes."

After one of the men shot a 2-year-old male American bison on November 11, Byrd writes an extensive description of the massive shoulders of the animal, as well as of its legs, horns, hair, and herding behavior. Two days later a beaver was brought in, prompting Byrd to write "Beavers have more instinct, that half-brother of reason, than any other animal." "In their houses, they always construct a Sally-Port, both towards the land and towards the water, that so they may escape by one, if their retreat should happen to be cut off at the other. They ... are kept diligently at work by the Master Beaver, which by his age or strength has gained himself an authority over the rest. If any of the Gang happen to be lazy ... this Superintendent will not fail to chastise him with the flat of the tail, wherewith he is able to give unmerciful strokes." Later he describes both how the Indians snare beavers and how the English make an extract from the castor glands to use as a lure to improve trapping efficiency.

The Indian shot a river otter three days later, commenting that the flesh tasted too much like fish to interest others as food. Soon thereafter, with winter coming and their horses in increasingly poor condition, the survey party turned back east, despite not having completed their duties of identifying the boundary all the way to the west.

Thomas Jefferson had a keen interest in science, especially in fossils of large mammals. He had been given fossil bones of *Megalonyx*, a giant ground sloth,

taken from a salt cave in Greenbrier County, [now West] Virginia (1799) and later he used the massive dimensions of mammoth bones to illustrate that North American mammals were not puny. His curiosity about the possible presence of these mega-mammals in the newly acquired 1803 Louisiana Purchase in part led to his organizing the expedition to the Northwest Territories. Further, he requested his hometown friends, Meriwether Lewis and William Clark, to send regular messages, and specimens, of new biota they might encounter on their search for a Northwest Passage. They sent reports of mountain goats (*Oreamnos americanus*), prairie dogs (*Cynomys* spp.), and grizzly bears (*Ursus arctos horribilis*), among other species new to science, but none on the extinct megafauna Jefferson was hoping they would find.

In his book, Jefferson (1781) wrote that "Our quadrupeds (mammals) have been mostly described by Linnaeus and Mons. de Buffon." Although he admired the Count de Buffon greatly as the naturalist "who is the best informed of any who has ever written," he faults him for his opinions that mammals "common to both old and new worlds are smaller in the latter ... and that those domesticated in both have degenerated in America ... and on the whole it exhibits fewer species." Buffon attributed these shortcomings to the *cold* and *moisture* in America.

Jefferson (1781) then sets about providing the evidence to counter and overturn these charges that American mammals are puny, degenerated, and few, first with a 3-page table with column headings of mammals common to Europe and America and their comparative weights. "The result of this view then is, that of 26 quadrupeds common to both countries, 7 are said to be larger in America, 7 of equal size, and 12 not sufficiently examined. So that the first table impeaches the first member of the assertion, that of the animals common to both countries, the American are smallest, and that without any exception."

Later, Jefferson (1781) wrote "there are 18 quadrupeds (*notice the number has shrunk*) in Europe; more than 4 times as many, to wit 74, peculiar to America; that the first of these 74 (i.e., the mammoth) weighs more than the whole column of Europeans (species); and consequently this second table disproves the second members of the assertion, that animals peculiar to the new world are on a smaller scale ..." Thus, Jefferson was a strong advocate for and defender of American science, including its mammals.

A nearly 100-year gap exists in the Virginia mammal record, from Jefferson to Edwin Drinker Cope's (1868) report of finding an eastern (now Allegheny) woodrat nest in Spruce Run Cave in Giles County, Virginia. Despite the Smithsonian Institution's National Museum of Natural History (NMNH) having been founded in 1855, the first Virginia specimens were not deposited into the collection until 1885 and 1886 when C. H. Merriam deposited house mice (ironically, a non-native species) collected from Old Point Comfort.

The first systematic study of mammals in Virginia began in 1895 when C. Hart Merriam, soon to become head of the US Bureau of Biological Survey (the forerunner to the US Fish and Wildlife Service), sent his assistant A. K. Fisher to begin what was to become a four-year study of the biota in the Dismal Swamp of southeastern Virginia. After taking an overnight steamer from Washington, D. C. to Norfolk and a train to Suffolk, with the help of a man from Suffolk, Fisher reached the shores of Lake Drummond in the center of the Swamp near sundown on the second day, 1 June. After six days of tending 50 Cyclone (break-back) traps alone and of shooting birds by day and bats at night, he was joined by Merriam for two nights and one day; they trapped an additional night near Suffolk on the way back to Washington, D. C.

In what Charles O. Handley, Jr. (2000) considers to have been a reconnaissance trip, Fisher and Merriam collected a marsh rabbit, four bats of two species, two species of shrew, 5 species of rodents, and a 'pick-up'' bear skull. Both shrews were described as new species that year by Merriam (1895), and in the next two years he named new species of southern bog lemming (1896) and muskrat (1897) from specimens collected in the Dismal Swamp. A fifth new species, a meadow vole, was named by Rhoads & Young (1897) from specimens collected for the Academy of Natural Sciences in Philadelphia. Collectors from two other eastern US museums also spent time in the Dismal Swamp during the 1895-1898 period. During 23 weeks of field work, they acquired nearly 270 specimens of 31 species of large and small mammals. Five species new to science were among them, all now reduced to subspecies status in later taxonomic revisions. Nevertheless, the efforts of these several collectors significantly advanced understanding of mammals in Virginia.

It might be asked why the Dismal Swamp was a focus for collections in the late 19th century. A recent invention, the Cyclone mousetrap, may have been important. (Previously, small mammals had been collected one at a time using guns, caught by hand, or dug from nests.) Merriam recognized that with a bag full of Cyclone traps, one person could collect a series of small mammals of a given species, leading him to champion the notion that series of specimens were important in the study of variation among geographic populations. Charles Handley (2000) believed the reasons related to interest derived from earlier studies of fishes in the Dismal Swamp (Jordan, 1888; Shaler,

1894). Merriam's interest in the taxonomy of bears was relevant too, because Shaler (1894) had commented on their abundance in the Swamp. A further reason might have been proximity; only short boat and train rides separated Washington, D. C., Suffolk, and the Swamp. The last part of the journey likely was the hardest, for although Fisher rowed a boat from Suffolk to Lake Drummond in June, when he returned from 15 days of collecting in October the ditches were dry and the water level had dropped four feet in Lake Drummond, necessitating a six-mile walk, with equipment and specimens, down the track paralleling Washington[2] Ditch. Fisher's notes from his June and October 1895 trips into the Dismal Swamp have been transcribed by Darelyn Handley (2000).

Of the 7,453 Virginia specimens currently in the mammal collections at the NMNH, ca. 20 percent have C. O. Handley, Jr.'s catalogue numbers and I estimate that another 20 percent were collected by Handley's students and colleagues. Until his death in June 2000, Handley was the patriarch of Virginia mammalogy (Pagels, 2000). Handley grew up in Blacksburg where his father was one of the first professors to teach wildlife science courses at what is now called Virginia Tech. Handley's interest in mammals was manifested at a young age, and he catalogued his first specimen (a house mouse) in December 1938, when he was 14 years old. The next year he trapped mammals at Mount Rogers, Buffalo Mountain, near Wise and Blacksburg, among other places. During his teenage years, Handley sometimes collected with C. P. Patton, a mammalogist with whom he co-authored *Wild Mammals of Virginia* in 1947, when only 23 years old. (John Wendell Bailey [1946] had written the first book, *The Mammals of Virginia*.) By this age, Handley already was working at the Smithsonian, but he later took time off to complete his Ph.D. from the University of Michigan in 1955.

Although Handley retained a keen interest in Virginia mammals, his career research emphasis was with Neotropical mammals, especially bats and rodents. He made regular trips to Venezuela and later to Panama, where he documented the appearance of increasing numbers of bat species on Barro Colorado Island in Lake Gatun, both created 100 years ago during the construction of the Panama Canal. Handley was the head of the mammal technical advisory committee that worked with the Virginia Department of Game and Inland Fisheries (VDGIF) on assessing threatened and endangered mammals in the Commonwealth, and he authored those sections of the books on Virginia's rare, threatened, and endangered species (e.g., Handley, 1991). He taught Mammalogy at Mountain Lake Biological Station in Giles County 10 times between 1962 and 1978, and he frequently returned to the same locations, thus accumulating information on persistence or changes of species in a community (Handley, 1992).

Besides these students, Handley taught specimen preparation workshops at the NMNH (often using frozen small mammals he had collected at Mt. Lake) and occasionally he later went into the field with neophyte preparators who wanted experience in the field too. For example, D. I. Rhymer collected with Handley near Kilmarnock in September 1959, and in 1960 and 1961 they made collections together near Saltville, Clinch Mountain, and Laurel Bed. Rhymer returned to some of these locations and also collected at Falls Church from 1959-1961, eventually depositing nearly 300 specimens in the museum under his own catalogue. L. T. Diamond also was with Handley and Rhymer near Kilmarnock, collecting his first specimen in September, 1959. Similarly, D. Peacock and Handley trapped mammals together in Fairfax, Chantilly, and Annandale in January and February 1960 and at Ewing in June 1962. From 1960-1965, Peacock made collections at many other places, eventually depositing nearly 1,200 specimens into the national collection from such places as Merrifield, Centreville, Great Falls, Warrenton, Tappahannock, Midlothian, Cedarville, Point Royal, Waverly, Williamsburg, and Hampton. Peacock collected mammals, mostly small mammals, over a large area ranging from northern Virginia to Hampton Roads. These amateur collector colleagues of Handley made important contributions to learning the distributions of mammals in Virginia, as amateurs can do today.

Another of Handley's collecting associations was with John Paradiso, who eventually wrote a book on the mammals of Maryland. For three years in the mid-1950s, Handley and Paradiso, often in company with B. F. Feinstein and D. H. Johnson, made extensive collections on Chincoteague and Assateague islands on the Eastern Shore, the Pungo region of Virginia Beach, as well as Mountain Lake and Burkes Garden. Several hundred specimens were donated by these colleagues to the national museum. Handley realized that many regions of Virginia were poorly known for their mammals (the counties of the western shore of the Chesapeake Bay and the montane southwest are notable), and I believe he encouraged many of these colleagues to make collections to fill information gaps, after taking the time to teach each one how to record useful data for specimen tags and the importance of

[2]George Washington, a partner in the Dismal Swamp Land Company, surveyed his eponymous ditch in 1763 during one of his five visits to the Swamp. The land company's attempts to make the land arable by ditching failed then (as did all later attempts) and his financial interests in the Swamp property passed to his heirs after his death in 1799.

taking accurate and detailed field notes to accompany the specimens when they were deposited in the national collection. Pagels (2000) summarized Handley's studies of Virginia mammals.

Another occasional collaborator of Charles Handley was John F. Pagels, who taught Mammalogy and guided graduate students at Virginia Commonwealth University for 40 years, starting in 1969. Pagels also built a significant mammal collection; the nearly 16,000 specimens from the VCU Mammal Collection are now property of the Virginia Museum of Natural History (VMNH) in Martinsville. He conducted field research and wrote numerous papers on a range of species of small mammals and bats. With his captures of rock vole (*Microtus chrotorrhinus*) and northern water shrew (*Sorex palustris*) in Bath and Highland counties, respectively, Pagels recorded two species of small mammals previously unknown in the Commonwealth (Pagels, 1990; Pagels et al., 1998). He also conducted extensive field research to learn the extent of northern flying squirrel (*Glaucomys sabrinus*) populations in western Virginia (Pagels et al., 1990). Often in association with his students and colleagues, Pagels published many papers on shrews and rodents of field and forest (e.g., Pagels et al., 1992).

Jack A. Cranford was the mammalogist in the Biology Department at Virginia Tech from 1977 until his retirement in 2008. Primarily a physiologist, Cranford and his graduate students studied mammals in Giles and Montgomery counties as well as on the Eastern Shore of Virginia. His papers were often on nutrition and digestibility of foods related to body growth and behavior, and on the habitat associations of field and forest rodents (e.g., Cranford & Maly, 1990). Besides teaching Mammalogy classes on campus, Cranford taught the course for several summers at the nearby Mountain Lake Biological Station.

Robert K. Rose taught Mammalogy at Old Dominion University from 1979 until his retirement in 2003, but he also conducted field and lab research with mammals at the University of Virginia from 1974-1976. Most of his papers are on Virginia mammals, primarily oldfield species such as meadow voles (Longtin & Rose, 2012), hispid cotton rats (Rose & Mitchell, 1990; Green & Rose, 2009), marsh rice rats, and eastern harvest mice, but also some on forest mammals in the Dismal Swamp (Rose, 2000). Many studies, often with graduate students, focused on ecology, behavior, or reproduction. Several students studied shrews in the southeastern Virginia region and rodents in tidal marshes on the Eastern Shore (e.g., Bloch & Rose, 2005; Rose & McGurk, 2006).

Raymond D. Dueser is an ecologist who has worked extensively with Virginia mammals, first as a professor in Environmental Sciences at the University of Virginia (1974-1990), and since then until his retirement in 2009 as an occasional researcher while a faculty member of the Department of Fisheries and Wildlife Sciences at Utah State University. Dueser's research focused on the distribution of small mammals on the barrier islands off the coast of Virginia's Eastern Shore (Dueser et al., 1979), although some of his students conducted projects near Charlottesville. Dueser sometimes collaborated with Rose, John Porter, or Nancy Moncrief. In retirement, he is continuing his studies of barrier island mammals and his associations with colleagues.

After moving to Charlottesville to earn his graduate degrees, John H. Porter has remained as a research associate in the Department of Environmental Studies at the University of Virginia. One of his jobs is data manager for the Long-term Ecological Research (LTER) site on the Eastern Shore; another is as a data expert for the National Science Foundation, serving other LTER sites. Porter also has conducted long-term research on the Eastern Shore with Dueser and sometimes in association with Nancy Moncrief. His papers on Virginia mammals often are coauthored with colleagues (e.g., Porter & Dueser, 1982).

Nancy Moncrief has been Curator of Mammals at the VMNH since 1988, where her duties include Assistant Director of Research and Collections, oversight of the collections, and working with exhibits. She has an active research program on the genetics of tree squirrels and island populations of rodents (e.g., Moncrief et al., 2012)

Donald Linzey is the author of the most recent book on *Mammals of Virginia* (1998). In addition, he has written several papers on Virginia mammals since the late 1970s. The editor of the (1979) volume on Virginia's Threatened and Endangered species, Linzey now teaches at Wytheville Community College.

Richard J. Reynolds and Michael L. Fies are wildlife biologists with the VDGIF. Reynolds's publications are mostly about small mammals and bats, whereas those of Fies deal with rabbits, hares, and flying squirrels (e.g., Reynolds et al., 2009). Those currently studying Virginia bats with Reynolds include Karen Francl (Radford University) and Christopher Hobson and William Orndorff (Virginia Department of Conservation and Recreation, Division of Natural Heritage). Importantly, Reynolds and Fies have endorsed VDGIF funding for numerous studies of Virginia mammals.

Faculty members at other Virginia institutions also have increased our knowledge of Virginia mammals. At Virginia Tech, the contributions of wildlife professors are recognized, especially those of Michael R. Vaughan. Wildlife professors have published many

papers on mammals, mostly on game or fur-bearing mammals, since the 1970s (e.g., Lee & Vaughan, 2005).

Walter Bulmer (et al., 2000) and Ralph P. Eckerlin, each of whom taught for more than 35 years at the Annandale campus of Northern Virginia Community College until their recent retirements, took class field trips to many parts of Virginia, where they frequently collected small mammals. Eckerlin was especially interested in the parasites of mammals, and authored several papers on this subject. Numerous specimens prepared on these field trips are now in the collections of the VMNH, as is Eckerlin's flea collection.

Michael T. Mengak, formerly of Ferrum College and now at the University of Georgia, studied the biology and distribution of the Allegheny woodrat in its haunts in western Virginia, among other mammals (e.g., Mengak & Castleberry, 2008). Also, William J. McShea, a long-time researcher at the Smithsonian Institution's Front Royal facility, has published numerous papers on small and large mammals in Virginia, often with colleagues (e.g., McShea et al., 2003).

Finally, the contributions of dozens of graduate students should be acknowledged. Their short-term research projects, which often led to publications, have increased the knowledge of distribution and more frequently of the ecology or biology of one or more species. One of the most noteworthy of these is the black bear study of Eric C. Hellgren, conducted in the Dismal Swamp in the early 1990s; his Ph.D. study led to the publication of at least a dozen papers on that population (e.g., Hellgren & Vaughan, 2000). Among more recent graduates, A. Scott Bellows has authored a cluster of papers since 1999, on small mammals and bats in a range of habitats at Fort A. P. Hill (Bellows et al., 2001) and other places, mostly with Pagels and Joseph C. Mitchell, before earning his Ph.D. degree at ODU in 2007. Another significant contributor is John Orrock, like Bellows an MS student with Pagels, with many papers on Virginia mammals (e.g., Orrock et al., 2000).

In conclusion, mammalian wildlife in early America was so abundant that it seemed inexhaustible. This abundance led to its exploitation, overuse, and rarity so that by the late 19th century it became clear that mammalian wildlife had to be regulated by hunting seasons and bag limits. C. Hart Merriam insisted that effective regulation required basic knowledge and thus he emphasized the need for research (Cameron, 1929). Effective management of wildlife also requires information on the distribution and abundance of wildlife species, necessitating surveys that assess abundance and annual tallies of wildlife taken by hunters and trappers. The early 20th century was also a period of great interest in natural history in America, with many people making personal collections of mammals (e.g., Lewis, 1940), yielding even more information on distributions. Recognition that mammals were intrinsically worthy of study was formalized in 1919 when the American Society of Mammalogists was founded and began publishing its *Journal of Mammalogy*. Historically, mammals in Virginia went from being a curiosity and similar to or different from English mammals, to a resource to be exploited and later valued as American, to being regulated and given the protection of law, and finally to being intrinsically worthy of study for interesting features of their biology. Today, all mammals have the protection of law: fur-bearers and game species are regulated by seasons and bag limits, but others can be studied by investigators, including non-professionals, who have been granted the state permits needed to conduct scientific research.

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Emmett Reid Dunn and the Early History of Herpetology in Virginia

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ABSTRACT

The historical development of herpetology into a modern science in Virginia occurred in the early 20th century. Only brief observations on the use of reptiles by Indians for ornamentation and food and short notes on geographic occurrence and behavior occur in the state's historical literature. A small number of scientists published their observations on the amphibians and reptiles of the state from the mid-1800s to the early 1900s. It was not until Emmett Reid Dunn, a native of Alexandria, published the results of his research in herpetology beginning in 1915 that this discipline began to mature. By 1936, he alone had confirmed 72% of the amphibians and 77% of the reptiles now known to occur in the state. In this article, I review some of the observations in the historical literature, describe the life and influential contributions of E. R. Dunn, and include a brief overview of some of the publications by others that followed him up to the creation of the Virginia Herpetological Society in 1958. Although substantial contributions were written by others, the foundation of the modern study of herpetology in Virginia was laid down solely by the efforts of one person, the native Virginian E. R. Dunn.

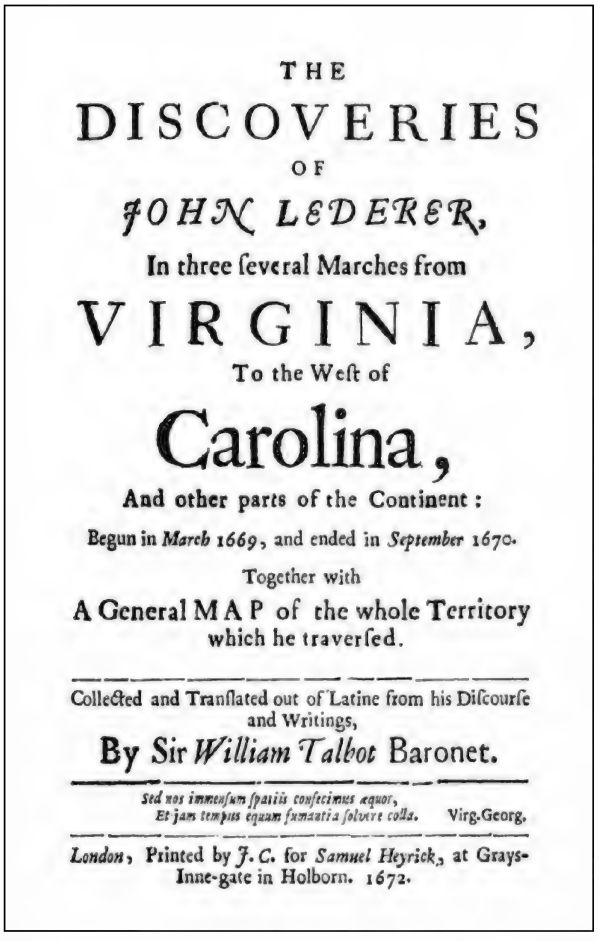
Key words: amphibians, Emmett Reid Dunn, history, reptiles, Virginia.

INTRODUCTION

Scientific disciplines seem to have lives of their own. In some cases one dedicated person provides the seminal foundation and in others a group of people working around the same time do so. For example, William Barton Rogers (1804-1882) conducted a state-supported geological survey of Virginia from 1835 to 1842 and produced the first accurate geological map of the state (Roberts, 1950). Mount Rogers is named in his honor, and he is considered the pioneer of geology in the state (Roberts, 1942). No one single person, however, can be recognized as the sole pioneer of botany (Hugo & Ware, 2012), ichthyology (Jenkins & Burkhead, 1994), mammalogy (Bailey, 1946; Rose, 2013), or ornithology (Johnston, 2003) in Virginia. Several individuals helped to establish these disciplines early on but no one person stood out. Although several scientists contributed papers to Virginia herpetology that can be considered relatively modern from a scientific point-of-view, only one person, Emmett R. Dunn, provided the foundation for all of what followed. Here I review some of the contributions to herpetology in the historical literature, describe the life of and scientific foundation established by Emmett Reid Dunn, and include a brief overview of some of the contributions by others that followed him. This review covers the period from 1612 to 1958 when the Virginia Herpetological Society (VHS) was created.

HISTORICAL OBSERVATIONS

The earliest published observations on the amphibians and reptiles of Virginia that appear in accounts found in the historical literature were printed in England. Captain John Smith published the earliest observations on reptiles, mostly as sources of food or how they were used by Indians for body ornamentation (Smith, 1612). During his first expedition in 1669, John Lederer discovered a squirrel in the stomach of a Timber Rattlesnake (*Crotalus horridus*) near what is now New Kent County (Lederer, 1672; Fig.1) but noted no other observations on reptiles. Herpetological observations made in the Colonial period were published in Robert Beverley's *The History and Present State of Virginia* in 1705. He noted six species of snakes, described aspects of snakebite, and said that frogs "do no hurt except by their noise of the croaking notes." Mark Catesby in his *Natural History of Carolina, Florida, and the Bahama Islands* (Catesby,



THE
DISCOVERIES
OF
JOHN LEDERER,
In three ſeveral Marches from
VIRGINIA,
To the Weſt of
Carolina,
And other parts of the Continent:
Begun in *March* 1669, and ended in *September* 1670.
Together with
A General MAP of the whole Territory which he traverſed.

Collected and Tranſlated out of Latine from his Diſcourſe and Writings,
By Sir *William Talbot* Baronet.

Sed nos immenſum ſpatiis confecimus æquor,
Et jam tempus equum fumantia ſolvere colla. Virg. Georg.

London, Printed by *J. C.* for *Samuel Heyrick*, at Grays-Inne-gate in Holborn. 1672.

Fig. 1. First page of the publication written by John Lederer in 1672 in which he provides the first observation of a rattlesnake prey item in Virginia and possibly North America.

1731-1743) added "The Noise they [Bullfrogs; Fig. 2] make has caused their Name; for at a few Yards Distance their Bellowing sounds very much like that of a Bull a quarter mile off." In his description of the survey that delineated the line between North Carolina and Virginia, William Byrd II (1728) noted several occurrences of rattlesnakes but little else. I can find only three publications on Virginia's herpetofauna in the period between Catesby's works and John E. Holbrook's volumes on herpetology in the middle 1800s. Castiglioni (1790) found a kingsnake (*Lampropeltis getula*) on the bank of the James River and Barton (1808, 1812) mentions the Hellbender (*Cryptobranchus alleghaniensis*).

Scientific papers, rather than historical or travel documents that include miscellaneous observations on selected species, did not appear until after John E. Holbrook published his series of seminal volumes on the amphibians and reptiles of North America between 1836 and 1842 (Adler, 1989). He included observations from Virginia in his accounts on four frogs, two lizards, two snakes, and seven turtles. Subsequently, a small number of authors published the first papers on the natural history of amphibians and reptiles in Virginia from a scientific perspective. Spencer F. Baird and Charles Girard (1853) described what they thought was a new species of snake (*Ophibolus clericus*) from Clarke County that is now known to be the Eastern Milksnake (*Lampropeltis triangulum*). Edward D. Cope (1895) noted a Rainbow Snake (*Farancia erytrogramma*) found on the bank of the Pamunkey River. A new species of treefrog (*Hyla evitatta*, now a synonym of *Hyla cinerea*) from the Washington, D.C. and northern Virginia area was described by Gerrit S. Miller, Jr. (1899). He also noted a Mole Kingsnake (*Ophibolus rhombomaculatus* [= *Lampropeltis calligaster*]) from Alexandria (Miller, 1902). Hugh M. Smith (1899) reported the Amphiuma (*Amphiuma means*) from Virginia for the first time. William P. Hay (1902) published the first checklist of amphibians and reptiles that included northern Virginia in its geographic scope.

EMMETT REID DUNN

It was not until Emmett Reid Dunn (1894-1956; Fig. 3) began exploring his passion for reptiles that modern herpetology in Virginia grew its first serious roots. He was born on 21 November 1894 and grew up in Alexandria. Little is known about his early years or the schools he attended. However, it is known from his publications that he spent considerable time on a

Fig. 2. The American Bullfrog (*Lithobates catesbeianus*) by Mark Catesby in his *Natural History of Carolina, Florida, and the Bahama Islands* (Catesby, 1731-1743). Image from a photograph taken of the painting online and reproduced in gray scale by Joe Mitchell.

Fig. 3. Emmett Reid Dunn, pioneer of the scientific study of herpetology in Virginia. This photo was taken at Midway, Nelson County, Virginia (date unknown). Photo courtesy of Mary Reid (Dunn) Barrow.

family farm adjacent to the James River at or near Midway Mills, or simply Midway (approximately 2 km N Wingina) in Nelson County. Dunn, like many who were to become professional herpetologists, was primarily interested in snakes when he was young. Living in Arlington allowed him to visit the Smithsonian Institution in nearby Washington, D.C. where he met Dr. Leonhard Stejneger (1851-1943), Curator of Reptiles and Amphibians. They established a life-long correspondence. Stejneger's letter to him in January 1913 so inspired Dunn that it set him on the path to become one of the most influential herpetologists in the first half of the 20th century. In that letter, Stejneger pointed out that the study of salamanders was far more in need of investigation than snakes (see the Foreword in Dunn, 1926). Salamander taxonomy and relationships were in a state of chaos in 1913 and had been since Cope's pioneering work on this group before the Civil War (Cope, 1859). At that time, Dunn was an 18 year old sophomore at Haverford College, a Quaker school, in Philadelphia. He was a good writer and when he became aware of the first scientific journal available on amphibians and reptiles, *Copeia*, which started in 1913, he found an outlet for his observations. The new journal was first published at the end of the same year that Dunn received his pivotal letter from Stejneger.

The year in which Dunn graduated with a BA, 1915, was the same year in which he published his first papers, mostly on observations from Virginia. Five of the eight papers he published that year were derived from his field work at Midway. His first scientific paper was on phenotypic variation in a litter of Northern Watersnakes (*Nerodia sipedon*) (Dunn, 1915a). His second Virginia paper was on the herpetofauna of Midway based on observations he made in the summers of 1912-1914 when he was 17-19 years old (Dunn, 1915b). He listed two species of salamanders, six frogs, five turtles, three lizards, and 17 snakes. Subsequent papers were on diet and reproduction in *Sceloporus undulatus* (Eastern Fence Lizard) (Dunn, 1915c) and reproduction in four species of snakes (Dunn, 1915d). He published a list of 25 species he observed in Clarke County in August 1915 (Dunn, 1915e). He reported late seasonal activity dates for nine species observed in late November at Midway (Dunn, 1916a). He also showed that the male vocalizations of the American Toad (*Bufo* [= *Anaxyrus*] *americanus*) and Fowler's Toad (*Bufo* [= *Anaxyrus*] *fowleri* could be used reliably to tell them apart (Dunn, 1916c). He recorded the first Northern Pine Snake (*Pituophis melanoleucus*) and Southeastern Crowned Snake (*Tantilla coronata*) in Virginia (Dunn, 1917c, 1919). In 1920, he added *Clemmys* [= *Glyptemys*] *insculpta* (Wood Turtle) and *Stereochilus marginatus* (Many-lined Salamander) to the Virginia checklist (Dunn, 1920a). He wrote the first checklist and key on Virginia's amphibians and reptiles based on records from 60 counties (Dunn, 1918a).

Dunn described *Desmognathus monticola* (Seal Salamander; Fig. 4) in 1916 based on specimens in the Smithsonian Institution, some of which were from six localities in the northern Blue Ridge Mountains (Dunn, 1916b). This was his first description of a formerly unrecognized species. Other papers, such as those on herpetofaunal records in Virginia and surrounding states (Dunn, 1920b) and the habitats of plethodontid salamanders (Dunn, 1928), were broad in scope but included specimens and observations from Virginia. He showed that the ranges of *Desmognathus fuscus* (Northern Dusky Salamander) and *D. monticola* overlapped extensively in the Virginia mountains (Dunn, 1917a). He pointed out that the treefrog described by Miller (1899) was a geographic variant of the Green Treefrog (*Hyla cinerea*) (Dunn, 1937). He

Fig. 4. *Desmognathus monticola* from near Sky Meadows State Park, Fauquier County, Virginia, a species described originally by E. R. Dunn in 1916. © John White - Virginia Herpetological Society.

was the first to consider the importance of sympatric species and salamander community structure (Wake, 1972). This body of work illustrates his developing wide breadth of interests.

Dunn graduated with a MA from Haverford College in 1916 and accepted a teaching job at Smith College in Northampton, MA. During that summer, however, he set out on his first major field trip, the one that started him on the path to become the world's expert on plethodontid salamanders. Mary Dickerson (1866-1923), Curator of Herpetology at the American Museum of Natural History (AMNH) in New York, had offered to sponsor him on a collecting trip to the mountains of North Carolina primarily to collect and study salamanders (Schmidt, 1957; Adler, 1989). The approximately seven week-long trip resulted in a major collection of amphibians and reptiles from that region. In the document that followed (Dunn, 1917b), he described the new salamander he found as *Plethodon yonahlossee* (Yonahlossee Salamander; Fig. 5) and what he thought was a new species of small turtle (*Clemmys nuchalis*). This name was later placed in synonymy with the Bog Turtle (*Clemmys* [= *Glyptemys*] *muhlenbergii*) (Schmidt, 1953). The trip culminated with a week at Midway for additional collecting. This trip solidified his primary scientific interest – to describe new species. This was the era when finding and describing new species was the measure of a professional herpetologist (Conant, 1997). Dunn wanted to be a member of this group and from the perspective of time he accomplished that even before he finished graduate school.

Dunn's teaching position at Smith College began in the fall of 1916 but he had to serve in the military briefly during 1917-1918 due to the need for men in World War I. He never saw combat or left the United States. He returned to his teaching position in late 1918 and for the next three years worked there and on his Ph.D. degree at Harvard University, which he completed in 1921. Additional papers on salamanders and other topics were published annually during this period. His first big project after completing his terminal degree was to write the book *The Salamanders of the Family Plethodontidae* (Dunn, 1926). Many of the salamander specimens he examined for this pivotal publication were from Virginia. This book contains the most detailed systematic analysis of any group of amphibians ever attempted previously (Wake, 1972). The impacts to herpetology of these early systematic works that he completed before he started in his Ph.D. program (Dunn, 1917a, 1918b; Fowler & Dunn, 1917) and his book on salamander systematics, evolution, and ecology cannot be overemphasized (Wake, 1972).

Although Dunn's herpetological interests expanded greatly after graduating from Haverford, he remained interested in the amphibians and reptiles of Virginia until at least the late 1930s. He maintained an active checklist of Virginia species until that time and added county records to it as they became available. This unpublished, but well-researched checklist (Dunn, 1936) was printed on mimeographed paper; copies were made available to colleagues and institutions. The one I describe here is in the reprint library in the Division of Amphibians and Reptiles, Smithsonian Institution.

The checklist that Dunn published on Virginia herpetology in 1918 (Dunn, 1918a) listed 36 (15 frogs, 21 salamanders) species of amphibians and 44 reptiles (12 turtles, 6 lizards, 26 snakes). His unpublished and expanded checklist that he maintained until 1936 increased the numbers to 53 amphibians (20 frogs, 33 salamanders) and 47 reptiles (12 turtles [exclusive of the unconfirmed sea turtles], 7 lizards, 28 snakes). He added 20 species in the intervening 18 years (17 amphibians, 3 reptiles). The largest gain was the addition of 12 salamanders. For comparison, the checklist by Mitchell & Reay (1999) includes 74

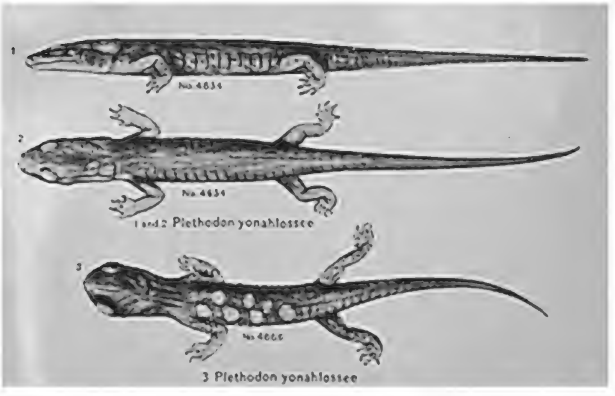


Fig. 5. First illustration of the Yonahlossee Salamander (*Plethodon yonahlossee*) by E. R. Dunn in 1917.

amphibians (25 frogs, 49 salamanders) and 61 reptiles (22 turtles, 9 lizards, 30 snakes). The addition of the Southern Chorus Frog (*Pseudacris nigrita*) by Moriarty & Hobson (2003) illustrates the continued refinement of our understanding of the herpetofauna of Virginia and increased the total to 137. Dunn had confirmed 72% of the known amphibians and 77% of the known reptiles 69 years earlier and much of it was due to his own efforts.

The 1936 checklist almost coincides with E.R. Dunn's change of focus away from Virginia. His paper two years later on the characters that distinguish *Acris crepitans* (Northern Cricket Frog) from *Acris gryllus* (Southern Cricket Frog) and their geographic distributions (Dunn, 1938) included many observations he had made in Virginia. It was his last contribution to herpetology in the state. Of the 217 publications Dunn would author in his lifetime, 21 were on Virginia's herpetofauna. These contributions, combined with the 1936 unpublished checklist, provided the all-important knowledge of what and where these species occur in the state, as well as basic knowledge of their ecology.

Dunn continued to teach at Smith College until he resigned in late 1928 to travel under a Guggenheim Fellowship to the tropics and the museums in Europe (Mitchell & Smith, 2013). After his return in the fall of 1929, he obtained a faculty position at his *alma mater* Haverford College where he would remain until his death from cancer on 13 February 1956 (Conant, 1956; Adler, 1989).

E. R. DUNN TO THE VIRGINIA HERPETOLOGICAL SOCIETY

E. R. Dunn's influential book on plethodontid salamanders (Dunn, 1926) opened a new world of research into the natural history, systematics, and ecology of this diverse group of vertebrates. Many herpetologists who worked on Virginia's herpetofauna after the 1920s focused largely on salamanders in the Blue Ridge and Appalachian mountains. Research on the other taxonomic groups began to grow in the 1930s as well and expanded thereafter over the next several decades. Little of this work could have been undertaken without Dunn's 1926 plethodontid salamander book and the groundwork he provided in the first taxonomic checklists for the state.

Several biologists focused on salamanders, as well as the other taxonomic groups in the 1920s through the 1940s. Henry W. Fowler (1878-1965) noted the first record of *Scaphiopus holbrookii* (Eastern Spadefoot) for Virginia (Fowler, 1918) and later published distribution records for Accomack, Augusta, and Loudoun counties (Fowler, 1925). Harry A. Allard (1880-1963) published four papers on the natural history of the box turtle based on captive observations of individuals caught in northern Virginia (Allard, 1935, 1939, 1948, 1949). He also described the call of *Bufo* (= *Anaxyrus*) *fowleri* (Allard, 1916) and reported on an albino Eastern Wormsnake (*Carphophis amoenus*) from Arlington (Allard, 1945). Maurice K. Brady (1904-1958) described the eggs of *Desmognathus phoca* (= *D. fuscus*) in Loudoun County (Brady, 1924a), and reported *Pseudotriton ruber* (Red Salamander) and what he thought was a Bog Turtle from Fairfax County (Brady, 1924b, c). The turtle was actually a juvenile Wood Turtle (Mitchell, 1989). He provided lists of the amphibians and reptiles observed in the Dismal Swamp and on Hog Island in the James River (Brady, 1925, 1927). A checklist and natural history notes on 18 species from Stafford County and a description of morphological variation in *Terrapene carolina* (Eastern Box Turtle) from northern Virginia were published by W. Gardner Lynn (1905-1990) in the 1930s (Lynn, 1936, 1937).

Several authors followed Dunn's lead and worked on salamanders in Virginia in the 1940s and beyond. M. Graham Netting (1904-1996) added new distributional records (Netting, 1932; Netting et al., 1946; Netting & Wilson, 1940). The first studies on salamander ecology and reproduction were conducted by Clifford H. Pope (1899-1974) and his colleagues. They evaluated growth and reproduction of the Slimy Salamander (*Plethodon glutinosus*) (Pope & Pope, 1949; Pope, 1950) and were the first to study the elevational distributions of plethodontid salamanders from an ecological perspective (Pope & Hairston, 1947; Pope & Pope, 1949). Pope and James A. Fowler (1916-2008) described a cave-dwelling form of Wehrle's Salamander as *Plethodon dixi* (= *P. wehrlei*) and named it after the public cave in which the original specimens were collected (Pope & Fowler, 1949). Fowler was the first to publish a report on an introduced species in the state, the False Map Turtle (*Graptemys pseudogeographica*) in the Potomac River near Washington, D.C. (Fowler, 1943b). He also contributed locality records for several amphibians and one snake (Fowler, 1943a, 1944, 1945, 1947; Fowler & Hoffman, 1951), as well as notes on the behavior and reproduction of *P. dixi* (Fowler, 1951, 1952).

Various aspects of the natural history of some of Virginia's Coastal Plain amphibians and reptiles were first published by Neil D. Richmond (1912-1992; see photo in Mitchell [1994: 12]), who succeeded Netting as the curator of herpetology at the Carnegie Museum of Natural History in 1954 (Adler, 2012). His family farm near Lanexa in New Kent County was the source of many behavioral and life history observations, some

of which were not corroborated until decades later (e.g., Richmond, 1944, 1945a, b, c, 1947, 1956; Richmond & Goin, 1938). He was the first to document the Glossy Watersnake (*Regina rigida*) in Virginia well north of its known range (Richmond, 1940).

Two other authors who began their studies in the 1940s would impact herpetology in Virginia for decades. Richard L. Hoffman (1927-2012; Fig. 6) wrote a number of papers while he was a teenager (Mitchell, 2009; Roble & Mitchell, 2012) on salamander and lizard distribution and systematics in the Virginia mountains (Hoffman, 1944a, b, 1945b, 1947, 1949, 1951; Hoffman & Kleinpeter, 1948a, b). He published the first checklist of the herpetofauna of Alleghany County (Hoffman, 1945a) and described the Virginia distribution patterns of the two species of Gray Treefrogs (*Hyla chrysoscelis* and *H. versicolor*) based on call differences 20 years before they were determined to be two separate species (Hoffman, 1946; Mitchell & Pague, 2011[2013]). Hoffman continued to make contributions to Virginia herpetology until the end of his life. Most of the papers that Roger Conant (1909-2003; Fig. 7) wrote on Virginia herpetology covered the herpetofauna of the Delmarva Peninsula (Conant, 1943a, b, 1945, 1946, 1958a; Conant et al., 1990). The first edition of Conant's field guide to eastern amphibians and reptiles (Conant, 1958b), like Dunn's 1926 book on salamanders, had a profound impact on herpetology in the eastern United States, and stimulated a new era of discovery and research in Virginia. This book was available to non-professionals, and that alone stimulated a surge in reports of distribution records backed by specimens donated to the Smithsonian Institution. The first set of distribution maps (Tobey, 1985) and faunal reviews (e.g., Mitchell, 1994; Mitchell & Anderson, 1994) on the Virginia herpetofauna are based in part on the foundation provided in this book.

Fig. 6. Two pillars in the history of herpetology in Virginia. Franklin J. Tobey (left), founder of the Virginia Herpetological Society, and Richard L. Hoffman (right), who contributed many papers starting in his teen years and after whom the salamander *Plethodon hoffmani* (Valley and Ridge Salamander) was named. The photo was taken at the VHS meeting in 1996 by J. C. Mitchell.

Fig. 7. Roger Conant at the 1982 Society for the Study of Amphibians and Reptiles meeting in Raleigh, NC. Photo © David B. Grim.

At the national level, several important books appeared in the 1940s and 1950s that were based in part on museum specimens from Virginia, as well as results of field work in the state. The handbook series published by Cornell University Press was the first to provide comprehensive descriptions of the natural history of all the salamanders (Bishop, 1943), lizards (Smith, 1946), frogs (Wright & Wright, 1949), turtles (Carr, 1952), and snakes (Wright & Wright, 1957) in the United States. These books established the context for many subsequent natural history studies that expanded our knowledge of herpetology in the state. All are still considered essential references.

The number of papers published on the distribution, ecology, and systematics of Virginia's herpetofauna continued to increase through the 1950s. Walter B. Newman (1925/26-1959) described a salamander

(*Plethodon jacksoni*) from Montgomery County, VA that he thought was new (Newman, 1954), but Highton (1962) placed it in synonymy with *P. wehrlei* (Wehrle's Salamander). He also described a new dusky salamander from the Blue Ridge Escarpment in Patrick County as *Desmognathus planiceps* (Newman, 1955). Martof & Rose (1962) placed it in synonymy with *D. fuscus* (Northern Dusky Salamander) because both forms were in the museum jar containing the type series and because they could not tell them apart. Tilley et al. (2008) resurrected Newman's *D. planiceps* (Flat-headed Salamander) based on morphology and molecular data and expanded its known range in southwestern Virginia and North Carolina. Newman, who had aspired to write a book on Virginia herpetology (R. L. Hoffman, pers. comm.), died at age 33 from a heart attack (note in the Newman reprint file in the Division of Amphibians and Reptiles, Smithsonian Institution).

Mountain Lake Biological Station, a field station in Giles County owned and managed by the University of Virginia (UVA), has played an important role in Virginia herpetology since the 1930s with courses in herpetology, animal ecology, and others that included field trips throughout the southern Appalachians (J. J. Murray, pers. comm.). Several projects resulted in publications. For example, Victor H. Hutchison (1931-present), who took classes there in the 1950s while a student at Duke University, contributed a paper on the herpetofauna of Giles County (Hutchison, 1956a) and two on the ecology of salamanders in the genus *Eurycea* (Hutchison, 1956b, 1958). E. R. Dunn taught a unit of herpetology in a course on vertebrates at the station in 1935 (J. J. Murray, pers. comm.).

John Thornton Wood (1919-1990; see photo in Mitchell [1994: 13]) moved to the College of William and Mary (W&M) from Columbia University in New York City in 1948. He completed his Master's degree on the nesting ecology of the Four-toed Salamander (*Hemidactylium scutatum*) at W&M in 1951 (Wood, 1951a). Between 1948 and 1956, the year after he completed his medical degree from UVA, he published 15 papers on amphibians and nine papers on reptiles (e.g., Wood, 1951b, 1953a, b, 1954a, b, 1955; Wood & Wilkinson, 1952a, b; Martin & Wood, 1955; Wood & Goodwin, 1955; Wood & Rageot, 1955; Goodwin & Wood, 1956). Wood also helped to establish the VHS in 1958, became its first president, and then moved to Canada in the early 1960s to continue his medical practice (Mitchell, 1994).

Another person who studied herpetology in Virginia and played an early role in the development of the VHS was W. Leslie Burger (1925-1988; see photo in Mitchell [1994: 13]). He was an undergraduate student at UVA in 1945, worked at the Virginia Fisheries Laboratory (which later became the Virginia Institute of Marine Science) in 1956, and taught at W&M from 1957 to 1959 (Mitchell, 1994; Adler, 2012). He made a number of valuable collections and documented several species new to the state but was unable to publish his observations. The checklist of amphibians and reptiles of Virginia that he developed (Burger, 1958) was used as the springboard for field work by the VHS.

Roger Conant's 1958 field guide was published in the same year that Franklin J. Tobey (1919-2010; Fig. 6) and others, including Burger and Wood, created the VHS (Tobey, 1988). This third oldest regional society in the United States stimulated the interest of many amateurs and several young people who later became professors at leading universities in the United States. Conant's book and the initiation of the VHS signaled the start of a new era in Virginia herpetology.

CLOSING THOUGHTS

Emmett Reid Dunn brought Virginia into the modern era of scientific discovery with his checklists, papers on salamander systematics, and the 1926 treatise on plethodontid salamanders. Others who followed used his foundation to expand the exploration of Virginia herpetology into the middle of the 20th century and beyond. The vision of an expanding mushroom cloud captures the pace and productivity of the efforts of these scientists. Scientific productivity in the second half of the 20th century and into the 21st century continued the expansion and indeed quickened the pace. The strides that have been and are still being made by the VHS on distribution patterns and natural history has brought numerous amateurs to the effort. Their contributions, along with those of professional herpetologists, will continue to elevate and expand the knowledge base on the amphibians and reptiles in the Commonwealth even further. We give due credit to the one person who started the modern era of herpetology in Virginia, Emmett Reid Dunn.

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Too many people than I can thank adequately here contributed in many ways to my understanding of the history of Virginia herpetology and the players that made it happen. I single out Richard L. Hoffman because he lived in and contributed to the period of expansion of knowledge of Virginia's herpetofauna, and because he showed me how valuable and rewarding it is to stand on the shoulders of those that came before. J. J. Murray, professor emeritus at UVA, provided information on herpetologists who worked or studied at

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History of Marine Biology in Virginia, with an Emphasis on Invertebrates

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ABSTRACT

The history of the study of marine biology in Virginia begins with the discovery and exploration of the Chesapeake Bay, the largest estuary in the United States. The Bay was first mapped and explored from 1607 to 1609 by Captain John Smith. At the time it was rich in marine life, including blue crabs, oysters, and clams and its waters were clean and transparent. The ease of water transport made the Bay the heart of early mid-Atlantic settlement. The population of the region had reached 1 million by 1800, but the region was still mostly rural, with Norfolk and Baltimore the major population centers. By the end of that century (1890) the human population had more than doubled, to 2.5 million, the watershed now including large towns and cities (e.g., Washington, D.C.), while new agricultural techniques and crops had led to erosion and nutrient enrichment of Bay waters. Around this time shellfish beds began to decline and a few scientists began to study the effects of human impacts on estuarine organisms and habitats, a process which continues to the present day.

The University of Maryland's Chesapeake Biological Laboratory was founded in 1925 and in 1940, the Virginia Fisheries Laboratory was established in Yorktown, but later moved to Gloucester Point and renamed the Virginia Institute of Marine Science (VIMS). Now part of the College of William and Mary, VIMS students and scientists pioneered studies of the biology of oysters and blue crabs, as well as other benthic organisms and fishes. Additional marine research, particularly in oceanography, takes place at Old Dominion University.

Key words: Chesapeake Bay, marine biology history, Virginia marine and estuarine biology.

INTRODUCTION

This paper is based on a talk given at the Virginia Natural History Society's 2009 symposium on the history of natural history in Virginia. It covers marine invertebrates and general marine biology of the area.

To the earliest explorers "Virginia" meant most of the southeast US coast. Thus, quotations used below may be based on writing by visitors to what are now North Carolina shores, but refer to animals also found in Virginia today. While there are numerous observations on land animals and plants, very few of the early explorers made any reference to marine animals, except those they considered edible or bizarre.

The history of marine biology in Virginia must also be evaluated in terms of the history of biology in the United States and the changing trends in emphasis in biological research world-wide. At the time of European settlement and for most of the Colonial Period biology was part of the great Age of Exploration. European naturalists visiting new regions of the world brought back samples of new life forms, plant and animal, to be described and classified, and where possible, some economic use determined. In the 19th century, exploration of terrestrial and marine diversity continued with the great scientific expeditions, which lasted into the early years of the 20th century, and whose results, in some cases, are still being tallied. Microscopes, invented before the beginning of the 17th century, were improved, allowing the 19th century development of comparative morphology, as well studies of developmental biology, phylogenetics, and genetics, all of which continued to be a focus during the 20th century (Mayr, 1982; Nyhart, 1995; Bowler, 1996).

MARINE AND ESTUARINE HABITATS

The marine and estuarine habitats of Virginia (Fig. 1) include the lower third of the Chesapeake Bay and the tributaries leading into it, the sounds and barrier islands of the open coast, and Virginia's Atlantic coast waters from the intertidal zone to the continental shelf. The Chesapeake Bay is the largest North American estuary. It is formed by the drowned valley of the lower Susquehanna River and developed over 15,000 years' time, and during a 300 foot rise in sea level. The Chesapeake Bay watershed covers 64,000 square miles; the Bay and its tributaries, 150 rivers, streams, and creeks, cover 4,500 square miles and includes 11,700 miles of shoreline (Pritchart & Schubel, 2001; Chesapeake Bay Program, 2009; USGS, 2012). The mainstem of the Bay is almost 200 miles long and holds 18 trillion gallons of water. It ranges in width from four to 30 miles, but its waters are very shallow, averaging only 21 feet deep. Tides are semidiurnal and salinity zones fluctuate, being influenced by rainwater input, currents, and weather conditions as well as the tidal surges.

Salinity in the main part of the lower Bay ranges from 10-18 ppt (mesohaline) to 32 ppt (oceanic salinity) at its mouth. Within the tributaries that enter into the lower Bay, the salinity becomes more and more diluted upstream until the water in the tributary is fresh. Sounds and inlets on Virginia's Eastern Shore have mostly higher salinities than the main Bay due to a smaller amount of fresh water input and less pollution.

Biogeographically, the Chesapeake Bay and the Atlantic beaches and waters from the intertidal zone to the continental shelf belong to the Virginian Province or subprovince. The Virginian marine biogeographic province extends from Cape Cod to Cape Hatteras and is considered a transitional region between cold and warm water marine faunas. Most benthic animals found there have wide distributions. Few species are endemic and the region is considered depauperate compared to the adjoining Atlantic Boreal and Carolinian regions (Briggs, 1974). The reason for this lack of diversity may be partly due to the lack of hard substrata and therefore of epibenthic organisms. It may also be related to wide seasonal variations in bottom temperatures (Franz & Merrill, 1980; Franz et al., 1981).

EARLY EUROPEAN EXPLORATION PERIOD

Captain John Smith, of the Virginia Company, landed near Lynnhaven Inlet, on 26 April 1607 (Williams, 2007). The Company settled in a location farther up the Bay, at Jamestown, on the north side of the James River. During explorations of their new land between late spring 1607 to fall 1609 (Williams, 2007), Smith and some of his men took smaller boats on trips covering most of the Bay and its navigable rivers. At that time Chesapeake Bay waters were clear and clean, with large fields of underwater grasses and vast expanses of oyster beds, making compelling propaganda for Smith to use to entice potential colonists (Wharton, 1973; Ernst, 2003; Williams, 2007; Chesapeake Bay Program, 2009).

The name Chesapeake came from the local Native American name "Chesepiooc", which has been variously translated as at the "great shellfish bay" or "at a big river" or "Great Water". Native Americans living along the mid-Atlantic coast had also given names to some of the larger invertebrates and fish, especially those that were edible. *Seékanauk* was their name for the horseshoe crab (*Limulus polyphemus*). In his *Briefe and True Report of the New Found Land of Virginia...*, Thomas Hariot (1590) wrote that the *Seékanauk* ". . . a kind of crusty shellfish, is a good food. It is about a foot wide, has a crusty tail, many legs, like a crab, and its eyes are set in its back. It can be found in salt-water shallows or on the shore." According to Hariot (1590), there were also "mussels, scallops, periwinkles, and crayfish."

Rare animals got more attention from the explorers than common ones, as did those that looked bizarre, such as the horsehoe crab. They were collected and taken back to Europe, at first as curiosity cabinet treasures, but by the mid-1700s, they were also collected for the purpose of being scientifically described by European scientists. Some, like the horseshoe crab, quahog (*Mercenaria mercenaria*), and soft-shell clam (*Mya arenaria*), were described by Linnaeus (1758). Other Chesapeake Bay species were named only slightly later, e.g., the oyster (*Crassostrea virginica*) by Gmelin (1790), the hydroid *Cordylophora caspia* (Pallas, 1771), and the sponge, *Microciona prolifera* (Ellis & Solander, 1786).

Thomas Hariot (1590: 256) made the first mention of ". . . large and small *oysters.* They are found in both salt and brackish water, and, as in our own country, those taken from salt water are the best." Before the 1800s, oysters and blue crabs, as well as other shellfish, were extremely abundant in the Bay, as European visitors documented in their writings. Englishman William Strachey (1612) wrote "Oysters there be in whole banks and beds . . . some thirteen inches long...." Another visitor, Francis Michel from Switzerland wrote in 1712 that "The abundance of oysters is incredible . . . there are whole banks of them so that the ships must avoid them. I often cut them in two, before I could put them in my mouth" (Michel, 1916).

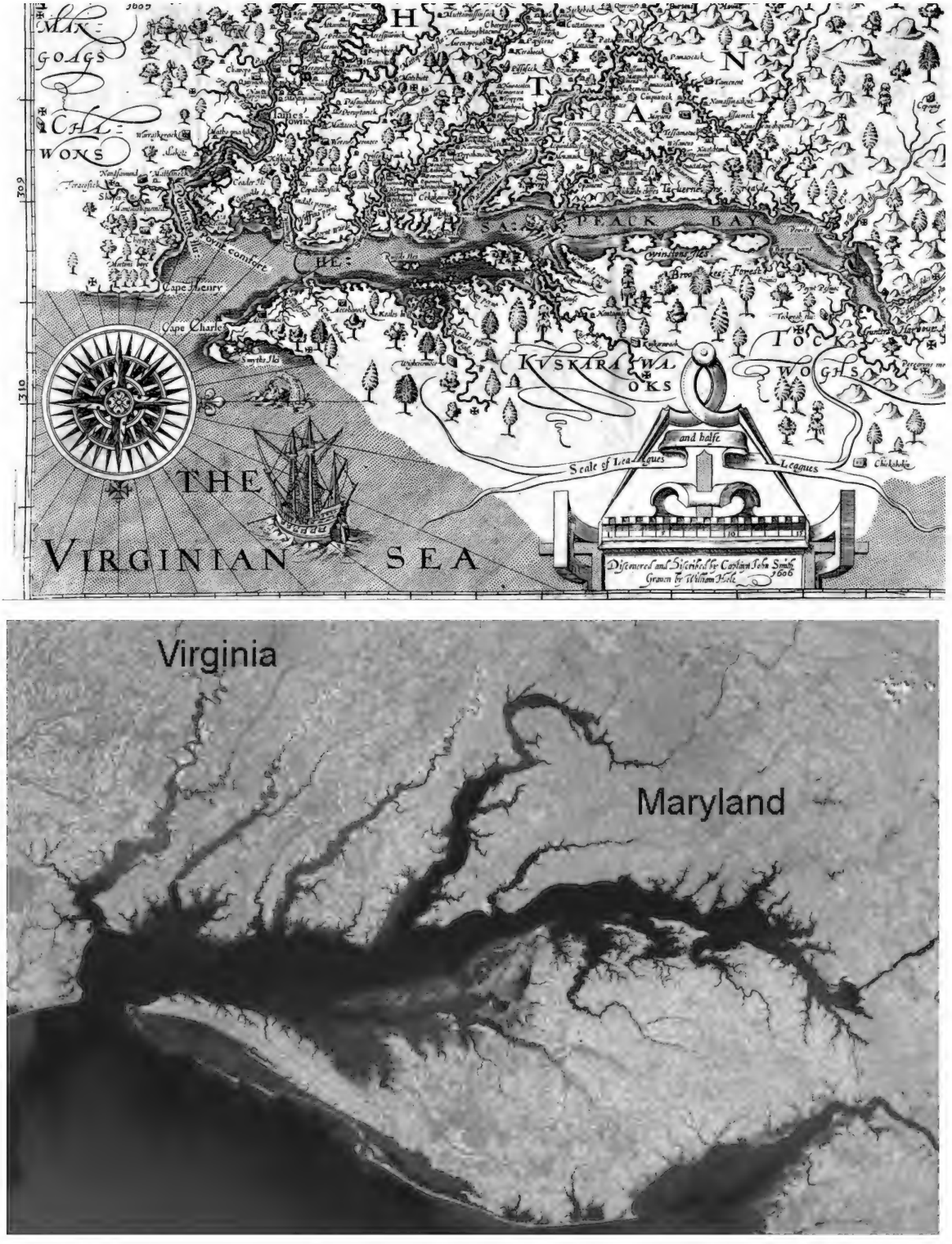

Fig. 1. The Virginian Sea and the Chesapeake Bay. Top: A portion of John Smith's 1612 map. Bottom: Landsat image in same orientation. (Note that north is on the right side of both images). (Sources: Top: Library of Congress website. 2013. John Smith's Map of the Chesapeake Bay. http://www.loc.gov/exhibits/treasures/ images/ s19.2.jpg (accessed 29 April 2013). Bottom: Image of the Chesapeake Bay taken from Landsat satellite data. VA, USA, image taken by US Geological Survey, NASA on 2 October 2009. Used courtesy of the US Geological Survey.)

HISTORY OF RESEARCH ON MARINE INVERTEBRATES FROM 1800

The 19th century marked the development of an American biology, with US scientists establishing research and teaching careers. Some of them had been trained at European universities, others at US institutions by transplanted Europeans such as Louis Agassiz. Most of their research was morphological and taxonomic in nature. Ecology had not yet developed as a separate discipline, although in the latter part of the century it was becoming clear to fishermen and legislators, as well as to scientists, that many of the country's terrestrial and marine resources, so plentiful in the 1600s, were being depleted (Ernst, 2003).

Oysters (Fig. 2)

The life cycle of the oyster is now a staple of life history theory; the "Elm-Oyster Model" describes organisms with a huge lifetime output of millions of sexually produced offspring (Williams, 1975). Consequently, oyster populations in the Bay would seem hard to destroy. Before contact and even for the first 250 years after European settlement this was the case. Native American populations along the Chesapeake Bay were relatively small at the time of European contact, and although shell middens indicate intensive harvesting at some sites, a lack of significant reduction in size of the oysters found in middens indicates that they were not being overharvested (Miller, 2001). In the 1700s, tonging for oysters was common along the Bay. They were at first considered poor people's food, but later a commercial oyster trade with other parts of the colonies developed (Wennersten, 2007).

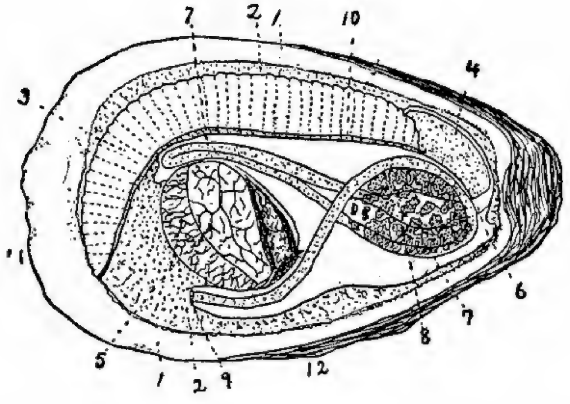

Fig. 2. The American Oyster *Crassostrea virginica.* Fig. 904 of Pratt (1916), a rendering of one of William K. Brooks's illustrations of oyster anatomy, from his reports to the Maryland Shellfish Commission.

In the early 19th century, with the arrival of northern seafood companies to open packing plants, a new way to harvest oysters by dredging was introduced to the Chesapeake Bay. Since dredging left few oysters on the bottom to reproduce and re-seed the population, the use of dredging had already depleted the northeastern oyster grounds around Cape Cod and Long Island. Dredgers headed for the still abundant grounds of the Bay, greatly expanding the oyster business up to the time of the Civil War. After the war, the use of another new technology, steam-canning, made long distance transport of the product possible (Wennersten, 2007).

During the 1870s, there was a great boom in oyster popularity. Oysters were shipped to England and Europe as well as other parts of the US. The competition for oysters led to a series of "oyster wars" between tongers and dredgers and between Maryland and Virginia over a disputed boundary separating the two states along the Potomac River and across the Chesapeake Bay to the Eastern Shore. Overexploitation by the dredgers led to "oyster piracy", forced servitude of immigrant laborers, and violence over the best remaining locations. The violence was controlled by the late 1880s, but oysters remained an extremely popular commodity up until the start of World War I. By the 1890s, the decline in oyster populations, from 15 million bushels harvested in 1884 to 10 million in 1890, had become obvious and initial inventory and conservation efforts had begun. However, they had little effect on the efforts of those involved in the industry to get their share of the dwindling resource (Wennersten, 2007).

The effects of two world wars and the intervening Depression reduced oyster harvesting. In the late 1940s and early 1950s, another oyster war between Virginia and Maryland erupted on the Potomac River, one which was finally settled by legislation in 1962. By that time oysters had other problems, including excess nutrient pollution, siltation, heavy metals, excess freshwater input from storms such as Hurricane Agnes (1972), and lack of adult oysters on which the oyster spat could settle due to removal of adult oysters and attached shell material. In addition to these environmental stressors, three new oyster diseases caused by protistan parasites, MSX, caused by *Haplosporidium nelsoni*, SSO, caused by *Haplosporidium costale*, and "Dermo" caused by *Perkinsus marinus* (Rothschild et al., 1994; Smith et al., 2003; Kemp et al., 2005; Kirby & Miller, 2005). Oyster harvests declined from 125 million pounds in 1880 to 25 million in 1978 and are still decreasing (National Oceanographic and Atmosperic Administration, 2013) (Fig. 3).

There are several new efforts to change this trend. They include rearing oysters to settlement stage, oyster

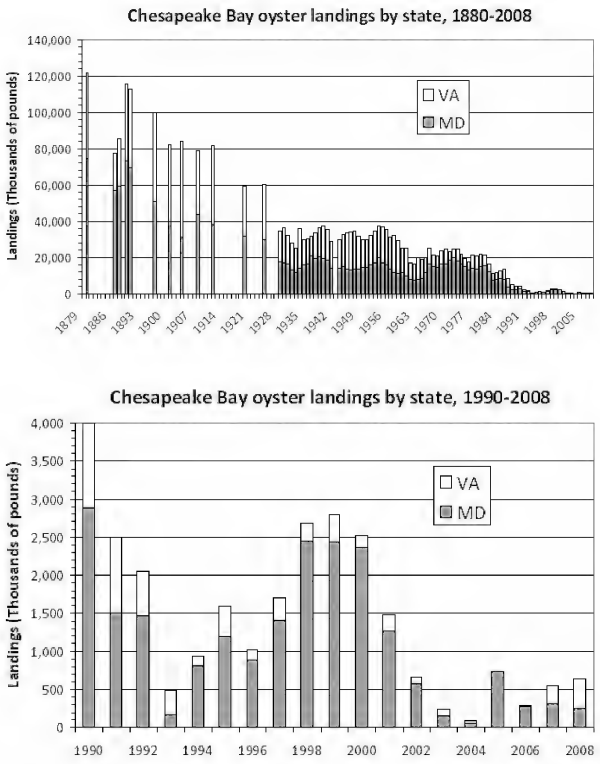

Fig. 3. Chesapeake Bay oyster landings by state, 1880-2008 (top) and 1990-2008 (bottom). Source: National Oceanographic and Atmospheric Administration. Chesapeake Bay Office website. Oysters. http://chesapeakebay.noaa.gov/fish-facts/oysters (accessed 29 April 2013).

aquaculture, and the restoration of hard grounds (e.g., dead oyster shells and other material) in areas where original oyster reefs were destroyed, ideally using areas where oyster banks had originally built up on hard paleo-terraces (Smith et al., 2003; Wennersten, 2007).

Blue Crabs (Fig. 4)

Like oysters, blue crabs (*Callinectes sapidus*) do not recognize the political division of the Bay into Maryland and Virginia portions, which has resulted in disputes over harvesting of those resources. Unlike oysters, blue crabs are mobile. Although male crabs venture farther up the Bay than females at some times of the year, mating takes place in the mid-Bay during summer and fall when the female crabs' shells are soft after molting. Following mating, the females migrate south to the mouth of the Bay, where they spawn and then carry the developing eggs until they mature into larvae. The planktonic larvae molt several times before turning into juvenile crabs that settle to the bottom where they can grow to adulthood in 12-16 months (Lippson & Lippson, 2006).

The blue crab harvest, like that of oysters, has sharply declined (Fig. 5, top) and for many of the same reasons, ranging from habitat loss (especially of the eelgrass beds and oyster bars that served as nursery areas for young crabs), declining water quality, loss of food sources due to benthic pollution and oxygen-deprived dead zones, as well as over-exploitation. In recent years, however, blue crabs have begun to make a comeback, in large part due to a cooperative agreement between Virginia and Maryland that has limited the numbers of female crabs that can be harvested (Pala, 2010; NOAA, 2012). Government fishery statistics for the last few years show blue crab populations finally beginning to increase to a sustainable level (Fig. 5, bottom). The most recent figures show the Chesapeake Bay blue crab population at a 20-year high level (Meola, 2012).

Description of Chesapeake Bay Marine Invertebrates

Although the first descriptions of marine animals found in the Chesapeake Bay were made by European scientists, by the 1800s American biologists were beginning to publish on their native flora and fauna. The 1972 compilation volume, "A Checklist of the Biota of Lower Chesapeake Bay, with Inclusions from the Upper Bay and the Virginian Sea" (Wass et al., 1972) is based on research at the Virginia Institute of Marine Science and earlier work (including Cowles [1930]), and lists all of the species known at that time. It can be used to document the increase in knowledge of the Bay's invertebrates. Taxonomic description of new species peaked between 1850 and 1899 for most marine invertebrate phyla. Some groups were described before others, for reasons that included size, accessibility (e.g., intertidal vs. dredged), the popularity of the group with collectors, and the regional interests and taxonomic specializations of the marine biologists involved.

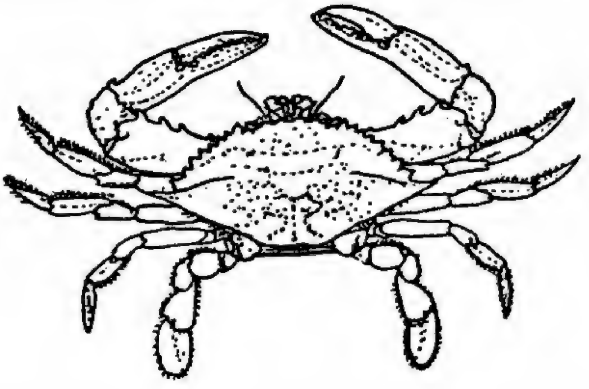

Fig. 4. The Blue Crab *Callinectes sapidus.* Fig. 634 of Pratt (1916).

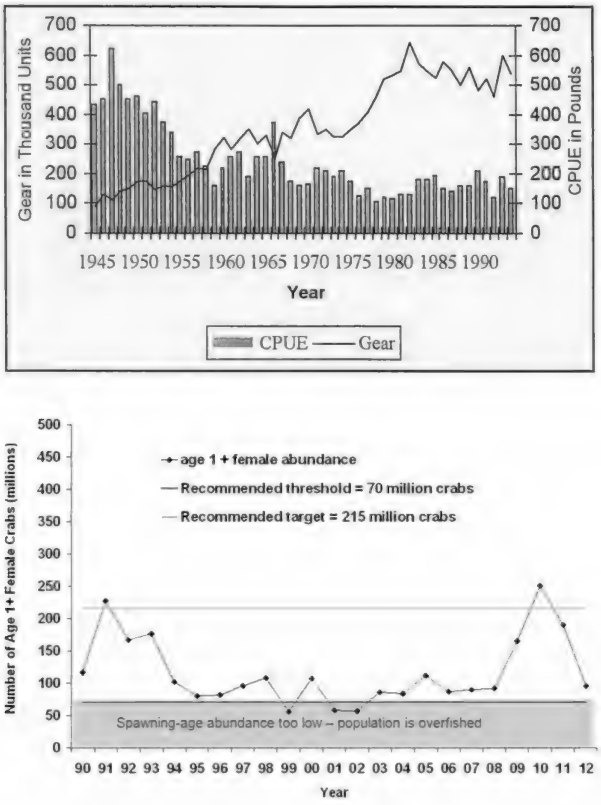

Fig. 5. Top: Fishing effort and catch per unit effort (CPUE) for the Chesapeake Bay Blue Crab Fishery, 1945-1990. Bottom: Abundance estimates of female and juvenile crabs from the annual Winter Dredge Survey 1990-2012. (sources: Top graph: Ernst, 2003, figure 5.2; Bottom graph: NOAA Chesapeake Bay Office, 2013. Blue Crab. http://chesapeakebay.noaa.gov/fish-facts/blue-crab (accessed 30 April 2013).

Table 1 shows the number of new Chesapeake Bay area invertebrate species described in each 50-year time interval in contrast to the cumulative number of species known in those phyla. By 1972, 823 species were known and the accumulation curve was beginning to flatten out, suggesting that most of the species in the Bay had been described by that time.

The same data set (Wass et al., 1972) can be used to document the peak intervals of description of new invertebrate species in different taxonomic groups

Table 1. Total number of Chesapeake Bay invertebrate species scientifically described from before 1750 to 1972 (as documented in Wass et al., 1972).

Time interval	Pre-1750	1750 -99	1800 -49	1850 -99	1900 -49	1950 -72
Per interval	8	73	190	305	146	101
Cumulative	8	81	271	576	722	823

Table 2. Scientific description of selected groups of Chesapeake Bay invertebrates from before 1750 to 1972 (as documented in Wass et al., 1972).

Time interval	Pre-1750	1750 -99	1800 -49	1850 -99	1900 -49	1950 -72
Mollusks	5	19	64	29	4	4
Crustaceans	3	20	81	136	166	29
Cnidarians	0	13	13	30	8	0
Annelids	0	7	15	70	13	11
Nematodes	0	0	0	15	39	52

(Table 2). Greater numbers of mollusks were described early in the time interval, which is not surprising considering their generally large size and the popularity of their shells with collectors. Arthropods followed, but more arthropods were not discovered until the 20th century as compared to mollusks. This probably reflects a later emphasis on the smaller and/or planktonic species of crustaceans, such as copepods and amphipods. Description of the cnidarians (e.g., hydroids, jellyfish, and sea anemones) also peaked during the second half of the 19th century. Annelid worms show a similar late 19th century peak in species descriptions published, but nematodes, which are mostly tiny or parasitic, were almost all described in the 20th century, with the number of new species still increasing in the second half of that century.

Taxonomic descriptions may provide important information on how species were collected and named, and, by comparison with present day collections, inform us as to whether their distributions have remained stable or changed. For example, Samuel F. Clarke (1882) described the hydroid *Eudendrium carneum*, from Fort Wool, in Hampton, Virginia, the site of a short-lived summer field station belonging to The Johns Hopkins University. Clarke (1882: 137) wrote, "The rocks forming the piers and also the spiles of the old wharf at Fort Wool are coated during June, July and August with immense quantities of these showy colonies that form a miniature forest, extending at low tide as far as the eye can reach." Although this species remains common on the southeastern US coast and Gulf of Mexico, by the 1970s it had apparently disappeared from the lower Chesapeake Bay (Wass et al., 1972).

Twentieth Century Biology

Biology during the 20th century saw increasing professionalization and specialization of biologists into narrower disciplines such as ecology, genetics, cell biology, physiology, oceanography, etc. Early 20th century research in the Bay was focused on surveys. Cowles' (1930) publication on the surveys of the

offshore waters of Chesapeake Bay described 250 organisms, but there was little or no coverage of some groups and only generic level identification for others. Taxonomic description of the organisms found in the surveys sometimes took decades after the end of the survey to complete. For example, the echiurid worm *Thallasema hartmani* was collected during a Fishery Service *Fish Hawk* cruise on 23 August 1920, but only described in 1947 (Fisher, 1947).

The Wass compilation shows that new species continued to be described between the 1930s and 1970, but at a much lower overall rate. Of the 68 named species of Cnidaria listed, only 3 were described in that time period. Of course, for groups in which there were one or more taxonomists working in the area, the pattern was different, e.g., six of the 15 named species of turbellarian flatworms were described in the 1930s or 1940s, thanks to the efforts of E. F. Ferguson and E. R. Jones, who were at the College of William and Mary, Norfolk Division, at the time. From the 1970s to today, most of the research focus has been on ecology and the effects of pollution and habitat degradation on the Bay and Atlantic shores, restoration ecology, biological studies of commercially important species like oysters and blue crabs, development of aquaculture, invasive species studies, and oceanographic exploration of the Bay and the offshore waters.

CHESAPEAKE BAY RESEARCH INSTITUTIONS

Academic Institutions

The history of academic institutions carrying out marine and estuarine research in the Bay begins, not with Virginia, but Maryland. The Johns Hopkins University was home to the Louis Agassiz-trained biologist Dr. William K. Brooks from 1873 to 1908. Brooks was very involved with work on the oyster for the Maryland Oyster Commission during the 1880s (see his diagram of oyster anatomy, Fig. 2), but he also founded the Chesapeake Zoological Laboratory to promote the study of marine and estuarine organisms in a summer program. The university did sponsor a summer field station in Virginia at Fort Wool in 1879 and 1880, but later Brooks' summer laboratory was moved to Beaufort, NC, and its scope was broadened to the marine animals of the Atlantic coast (McCullough, 1969).

The University of Maryland's Chesapeake Biological Laboratory was founded in 1925 by Dr. Reginald V. Truitt. It is located at Solomons, Maryland, on the Patuxent River, on the western shore in the middle region of the Bay. It is now an environmental research and graduate education facility of the University of Maryland Center for Environmental Science. Dr. Truitt was director of the Laboratory until his retirement in 1954. He was also director of the Maryland Department of Natural Resources' Department of Research and Education (Wikipedia article on R. V. Truitt, 2012; Chesapeake Biological Laboratory website, 2013). His own career was devoted mostly to research on oysters, but under his direction, a large series of economic, ecological, and taxonomic publications on Bay organisms was produced.

In 1940, College of William and Mary biology professor Dr. Donald W. Davis (Fig. 6) established the Virginia Fisheries Laboratory (VFL) in Yorktown, Virginia. Beginning that year, a master's program in Aquatic Biology at William and Mary trained marine scientists.

The Virginia Fisheries Laboratory was moved to Gloucester Point on the opposite side of the York River in 1950, and renamed the Virginia Institute of Marine Science (VIMS). Initially, it was an independent state institution, but it has been part of the College

Fig. 6. Donald W. Davis, biology professor at the College of William and Mary, who established the Virginia Fisheries Laboratory (now the Virginia Institute of Marine Science) in 1940. Photo courtesy of VIMS.

of William and Mary since 1979. VIMS scientists and students have pioneered studies of the biology of oysters and blue crabs, as well as other benthic organisms and fishes. VIMS blue crab and fish surveys have continued since 1955, and are vital tools for fishery management. Through the College of William and Mary, VIMS has granted more than 700 graduate degrees in marine science since 1968. VIMS is one of the largest marine research centers in the United States, and a leader in sea grass restoration, oyster aquaculture, and hard clam research at its Eastern Shore Laboratory (VIMS website, 2009, 2012).

Old Dominion University (ODU) was founded in 1930 as the "Norfolk Division" of the College of William and Mary. It became an independent college in 1962 and a university in 1969 (Old Dominion University website, 2012, 2013). The strength of Old Dominion's marine science research program is in oceanography, particularly the study of ocean margins and coastal systems research. Researchers at ODU have carried out many studies and surveys of the the lower part of the Bay, the Atlantic ocean off Virginia, and the Mid-Atlantic Bight (Dauer & Alder, 1995) as well as in other regions of the oceans (Brydges, 2000; Old Dominion University website, 2012, 2013).

State and Federal Agencies

Federal management programs in the Bay began after Spencer Fullerton Baird founded the U.S. Bureau of Fisheries in 1871. At that time a decline or disappearance in some of the upper Bay's fisheries (e.g., anadromous shad and herring) had been noticed (Mountford, 2000). The Bureau's early surveys were undertaken by the U.S.S. *Albatross* (limited to deeper waters of the Bay because of its greater draft) and the U.S.S. *Fish Hawk*. Both ships had been built specifically for oceanographic and marine biological research. The *Fish Hawk* was also built as a floating fish hatchery. Both ships were active from the 1880s to the 1920s. Surveys of the Chesapeake Bay and nearby Atlantic Ocean took place under Lewis Radcliffe (1915-17) and were continued by The Johns Hopkins University Zoology Professor Rheinart P. Cowles from 1920-22 (Mountford, 2000). The surveys resulted in the 1930 report on the "Biological Study of the Offshore Waters of Chesapeake Bay" by Cowles, which is still considered a classic work on the ecology and environments of the Bay.

The Smithsonian Environmental Research Center (SERC) is located in Edgewater, Maryland, but its scientists pursue research throughout the Bay as well as comparative studies in sites around the world. It began with a farm property on the Rhode River that was bequeathed to the Smithsonian Institution and now employs 17 resident scientists and a large group of associated scientists, students, and technicians (SERC website, 2012).

Other federal agencies have also played a role in monitoring and restoration of the Bay. In 1965, the U.S. Army Corps of Engineers received $15 million in funding through the Rivers and Harbors Act. They produced a seven-volume report in 1973 on existing conditions, and in 1977, another 12 volumes on future conditions (U.S. Army Corps of Engineers, Baltimore District, 1973). The U.S. Environmental Protection Agency (EPA) has been a major player in restoration efforts of the Bay. In 1976, the EPA was funded to carry out a second comprehensive study, which resulted in a report issued in 1983 (Hartigan, 1983).

Virginia state agencies involved in research and restoration of the Bay include the Virginia Department of Environmental Quality's (DEQ) Coastal Zone Management Program. The Virginia Department of Environmental Quality belongs to a partnership focused on restoration of the Chesapeake Bay and its watershed called the Chesapeake Bay Program along with partner states Maryland and Pennsylvania, the District of Columbia, and the EPA (Chesapeake Bay Program website, 2013). The Virginia DEQ contributes to the program in the areas of environmental monitoring, nutrient source production, and toxics reduction. Virginia's Marine Resources Commission regulates recreational and commercial fishing rules and licensing, and, under the Marine Police, provides enforcement of regulations, oversees boating safety, carries out search and rescue operations, and is responsible for Homeland Security matters.

VIRGINIA'S MARINE AND ESTUARINE ENVIRONMENTS: PRESENT AND FUTURE

Human Population Growth and the Decline of the Bay

Seventeen million people now live in the Bay's watershed (Chesapeake Bay Foundation website, 2011). The "State of the Bay" report on the health of the Chesapeake Bay by the Chesapeake Bay Foundation issued in December, 2010a compared the current health of the Bay, based on thirteen indicators, to its original state when Colonial settlers arrived (100%). Although the State of the Bay index has risen from 23% in 1983, when the first Chesapeake Bay Agreement was signed, to 31% for 2010, it is still listed as impaired by the EPA.

The indicators used are grouped into three general categories. *Pollution*: nitrogen, phosphorus, water

clarity, dissolved oxygen, and toxics, *Habitat*: forested buffers, wetlands, underwater grasses, and resource lands, *Fisheries*: rockfish, blue crabs, oysters, and shad. Although the overall score was just 31%, this percentage represented an increase in the scores of eight of the thirteen indicators. Thanks to the 2008 blue crab regulation changes, the blue crab populations increased, underwater sea grass habitat and forested buffers improved, as did some of the physical and chemical indicators (e.g., dissolved oxygen, water clarity), while the amount of toxics decreased. The decline of "dead zone" areas was a good surprise. The most recent report (2012; issued in February 2013) gives a 1% increase to 32%. Some indicators, such as dissolved oxygen levels, had improved, whereas others, including submerged vegetation had decreased (Chesapeake Bay Foundation website, 2013). More improvement will be needed to bring the Bay to a "stable" 50% of its original Contact period condition.

Much has been written about the politics of the efforts to save the Bay's health and resources (e.g., Schubel, 1986; Baliles, 1995; Ernst, 2003; Wennersten, 2007). There is more cooperation between the states and organizations in parts of its huge watershed, and that is a cause for some optimism, but it will take a much stronger willingness to confront the impact of activities to have a significant positive effect on the health of the Bay.

Physical and Biological Factors

Excessive amounts of nitrogen and phosphorus nutrients reaching the waters from urban, residential, and agricultural runoff are still a problem, although water clarity has improved very slightly. Dissolved oxygen has improved, but not enough to prevent many "dead zones" during summer months. The cleanup of part of the Elizabeth River has partially eliminated one of the most toxic areas in Virginia waters. Efforts to restore natural habitats ranging from wetlands and riparian buffers to oyster reef and seagrass meadows continue to be important in improving tributaries and Bay waters.

Introduced Marine Species

Non-indigenous species (NIS) are an increasing problem in coastal regions around the world (Ruiz et al., 2002; Foffonoff et al., 2009). Some introductions may be relatively benign. For example, the Sea Roach isopod, *Ligia exotica*, was introduced to North Carolina in the 1880s, and has spread from there along the Eastern seaboard with no known harmful effects on native organisms (Fofonoff et al., 2009). Other changes in distribution may not actually be invasions, but rather range extensions due to climate change, e.g., the bryozoan *Bugula neritina* did not occur in the Chesapeake Bay at the time of Wass's (1972) checklist. It is now found in the lower Bay (NEMESIS database, and VMNH collections). Some NIS may be aggressive and destructive to native organisms, e.g., the Veined Rapa Whelk (*Rapana venosa*) first seen in 1998, and now established in the Bay and spreading along the southeastern coast (Harding et al., 2011).

Blackfordia virginica, a hydrozoan jellyfish, is thought to be the first ballast water introduction (1904). It was described as a native to Virginia, but is now known as a Black Sea species that has invaded many other regions (Bardi & Marques, 2009; Fofonoff et al., 2009).

Fofonoff et al. (2009) list 170 non-indigenous species inhabiting the Bay. The earliest recorded introductions are for *Carcinus maenas*, the green crab (1874), *Corylophora caspia*, a hydroid (1877), and *Teredo navalis*, a shipworm (1878). Considering the Bay's long history of European settlement, they and others were probably living there for many years before they were scientifically documented.

THE FUTURE OF VIRGINIA'S MARINE ENVIRONMENTS

A large proportion of Virginia's population lives on the Coastal Plain or watersheds (e.g., James, York) that drain into the Chesapeake Bay. Despite more than 50 years of attempts to restore the Bay, our efforts have not yet restored it to even 50% of its original environmental condition. The populations of some important organisms, like the blue crab, are finally improving. The fate of others, like the oyster, are more uncertain. Oyster aquaculture and oyster reef restoration offer hope, but poaching of aquaculture holdings and leases and continuing pollution temper that hope (Chesapeake Bay Foundation, 2010b). If the oysters disappear, other suspension feeders, like the bryozoan *Alcyonidium verrilli* and the sponge *Microciona prolifera*, both very common in the channels of the lower Bay, may take their place ecologically, but not as sources of human food and icons for tourism. In the long run, the future of Virginia's marine environments is up to us.

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History of Araneology in Virginia

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ABSTRACT

At least from the 1600s to the present, spiders have been observed, collected, and studied in Virginia. This paper endeavors to outline the history of araneology in Virginia from its inception through the first decade of the 21st century, including researchers of spiders at Virginia institutions and those who have studied Virginia spiders.

Key words: araneology, history, spiders, Virginia.

INTRODUCTION

The study of spiders in Virginia has a venerable history, beginning in the 17th century and continuing to the present. Through the efforts of natural historians, entomologists, and ecologists, we know much about these important arachnids, but distributions and even the presence of some species in Virginia remain to be discovered. In the 20th and 21st centuries, quantitative, manipulative studies have increasingly replaced anecdotal observations, and spiders are used as model organisms to address ecological and evolutionary hypotheses.

17th Century

Perhaps the first person to collect spiders in Virginia was John Banister (1650-1692), an Englishman who arrived in Virginia in 1678. Banister was a careful observer; Lewis (1957) called science writers before Banister "historians rather than scientists." She judged that natural history in America actually began with Banister.

By 1680, Banister had composed a catalog of insects called *Collectio insectorum*. Spiders appeared under "*De Insectis Pedibus Octonis*"; harvestmen were called spiders; silverfish were called "stingless scorpions." As late as the time of Linnaeus, scorpions and spiders were placed with silverfish in the insect order Aptera (Ewan & Ewan, 1970).

Banister died when accidentally shot while botanizing on the Roanoke River in 1692, before seeing publication of his works on insects. He had been planning a *Natural History of Virginia* (Lewis, 1957). Instead, "Some Observations concerning Insects made by Mr. John Banister in Virginia, A.D. 1680" was published by Petiver (Banister & Petiver, 1701). Banister was the first to systematically describe any of the spiders of North America; not until between 1791 and 1802 did John Abbot draw the spiders of Carolina and Georgia (Ewan & Ewan, 1970).

Lack of proper attribution by Martin Lister (a 17th century physician and natural historian), who received Banister's specimens in 1680 and data for illustrations by Petiver, kept Banister's Virginia specimens from inclusion in Linnaeus's (1758-1759) *Systema Naturae* (Ewan & Ewan, 1992). Petiver's illustrations were sources for Linnaeus in his establishment of binomials (Ewan & Ewan, 1970). Since spiders were very much a side line to Banister's botanizing and Linnaeus did not knowingly use his collections, it is not surprising that Bonnet (1945) and others were not aware of Banister's contribution.

18th Century

Benjamin H. Latrobe (1764-1820), an Englishman who immigrated to Virginia in 1795-96, was considered the first professional architect in the U.S. and designed the Capitol in Washington (Library of Congress, 2009). His published journal (Latrobe, 1905) is a good example of the nature writing of that time. In it, Latrobe wrote extensively about a spider wasp and a spider near Fredericksburg that he manipulated to see how they would behave. He also opened the mud cells of some wasps and recorded the colors and sizes of the

paralyzed spiders within (no mention is made of any names for the spiders).

19th Century

Between Banister and the early work of Nathan Banks (1868-1953), it is difficult to find records of any Virginians who studied spiders. Banks was a student of John H. Comstock at Cornell University. A New Yorker by birth, he lived in Falls Church, Virginia and published on local spiders (among other taxa) while employed at the USDA in Washington (1890-1916). During this time he published a revision of Marx's 1889 catalog of Nearctic spiders (Banks, 1910). Banks moved to the Museum of Comparative Zoology at Harvard University, where he continued to publish on spiders until at least 1930. He described a number of new species of spiders (Bonnet, 1945), but none of his titles on spiders were specific to Virginia. Exceptionally prolific, Banks authored over 440 technical papers from 1890-1951 and had eight children.

James Henry Emerton, who wrote widely on spiders, including a book on the common spiders of the United States (Emerton, 1902), published a paper on cave spiders, including some in Virginia (Emerton, 1875). In Fountain Cave (Augusta Co.), he found "one young spider allied to *Tegenaria*" and in Weyer's Cave (Rockingham Co.) a species of *Linyphia* with normal eyes; he noted that some specimens of the latter species had colors as bright as those of spiders of the same family from cellars or shady woods.

Increasingly in the 20th and 21st centuries, cave animals are endangered, and several more recent papers include spiders of Virginia caves. John R. Holsinger at Old Dominion University has published several papers on cave faunas, including spiders. A list of all identified spiders that have been found in caves in Virginia (obligate and accidental) can be found in Holsinger & Culver (1988). A new review paper will include additional obligate cave spider records (Holsinger et al., *in press*).

In 1888, when the Virginia State Agricultural Experiment Station was established by an Act of Congress, serious work on insects was initiated in Virginia (French, 1950), but because spiders are not crop pests, they have never been studied as much as insects.

20th Century to Present

Between November 1936 and March 1937, there was a flurry of notes in *Science* by various authors concerning the distribution of the black widow spider (*Latrodectus mactans*). D. C. Lowrie began the conversation by saying that the black widow had not been officially recorded in eight states, including Virginia (Lowrie, 1936). G. W. Jeffers countered, "This must come as a surprise to the naturalists of the state," since the black widow was so prevalent that nobody bothered to mention it (Jeffers, 1936). B. J. Kaston returned that the black widow was first recorded from Hog Island in Virginia by J. H. Emerton in 1875 and was also recorded "as abundant in the Norfolk area by L. D. Anderson and H. G. Walker, and from various localities by C. R. Willey. Moreover, Dr. Bogen (Bogen, 1926) cites cases of arachnidism ..." (Kaston, 1937). In the same issue, H. A. Allard stated that he had found black widows in four places in Virginia within the last two years (Allard, 1937). R. L. Taylor, who was in the Department of Biology at the College of William and Mary, remarked sarcastically, 'If by "officially recorded," publication in a scientific periodical is meant ...' and documented a June 1936 paper in the *Quarterly Review of Biology* (Taylor, 1937). Lowrie must not have seen this document before he submitted his note in November of that year. Taylor continued, "With respect to Virginia, it was rather surprising to find it said that there was no official record from this state since the black widow is common to abundant in most of the state" and cited papers on bites in the *Virginia Medical Monthly*. Additionally, he said, the 1934-1935 *Proceedings of the Virginia Academy of Science* included a paper read by Elizabeth Burger, a graduate student at William and Mary, which included the incidence of arachnidism in Virginia. Taylor continued, "One spring day, Miss Burger and the writer took 50 individuals [black widows] ... from the stones of a rock-banded curbing 35 x 2 feet in area" [in the vicinity of Williamsburg] (Taylor, 1937). Elizabeth Burger (Jackson)'s unpublished Master's thesis focused on the black widow spider (Jackson, 1935).

During the latter part of the 20th century until the present, a number of researchers, faculty, and graduate students in Virginia have studied Virginia spiders. However, many spider distributions in the state remain unknown.

Richard L. Hoffman (1927-2012), Curator Emeritus of Recent Invertebrates at the Virginia Museum of Natural History (VMNH) in Martinsville, was a native Virginian who devoted most of his life to the natural history of Virginia and the southern Appalachians, while being the leading authority on the world's millipeds. Hoffman's collection of spiders at the VMNH is the largest in the state, and he kept records of all Virginia spider species based on published literature and this collection. He published 485 scholarly books and papers and over 50 popular articles on millipeds,

amphibians, reptiles, worms, mollusks, arachnids, beetles, and true bugs; described more than 600 new taxa, including a species of *Hypochilus* from Virginia and West Virginia (Hoffman, 1963); and had nearly 50 taxa named in his honor (Roble & Mitchell, 2009). Among his numerous publications on spiders were lists of Virginia purse-web spiders (Atypidae), anyphaenids (Anyphaenidae), ground spiders (Gnaphosidae), and grass spiders (*Agelenopsis*) (e.g., Hoffman, 1992, 2000, 2002, 2009, 2010); removal of *Theridion montanum* (Theridiidae) from the Virginia faunal list (Hoffman, 1996a); a description of the type locality and distribution of *Xysticus emertoni* (Thomisidae) (Hoffman, 1996b); and addition of new species such as *Araneus saevus* (Araneidae), *Arachosia cubana* (Anyphaenidae), *Anahita punctulosa* (Ctenidae), and *Drassyllus rufulus* (Gnaphosidae) to the Virginia fauna (e.g., Hoffman, 1997, 2006; Hoffman et al., 2006; Roble & Hoffman, 2012).

Due to the difficulty in maintaining collections of spiders in alcohol, rather than dry, as for insects, some museums do not accept donations of private collections. Thanks to the interest of Richard Hoffman, the VMNH, established in 1988, houses thousands of spiders from Virginia. Soon after the Museum opened, Bill Shear, who was chairman of its Board of Directors, donated his personal spider collection of over 900 vials containing about 300 species (Hoffman, 1991). Shear's collection was mainly from outside Virginia, but Hoffman embarked upon an ambitious effort, in concert with the Virginia Division of Natural Heritage, to sample arachnids across the state. He expected to gather about 800 species of arachnids from Virginia. Thousands of mega-arachnids (not mites) were collected prior to 1991; these yielded a number of new state records and range extensions (Hoffman, 1991). Many more spiders were added to the VMNH collection up until Hoffman's death in June 2012.

At the Ninth International Congress of Arachnology in Panama in 1983, James E. Carico (1937-2009) of Lynchburg College proposed a "new" American spider family, the Trechaleidae (Carico, 1986b). He published revisions of genera in that family as well as in the Pisauridae (e.g., Carico, 1973, 1976, 1993, 2005a; Da Silva et al., 2008), studies on the behavior and anatomy of spiders in these families (e.g., Carico & Holt, 1964; Carico, 1986a; Bruce & Carico, 1988; Costa-Schmidt et al., 2008), and descriptions of new genera (e.g., Carico, 2005b). Carico served terms as President of the American Arachnological Society and Editor of its publication, *The Journal of Arachnology.*

James O. Howell completed his Master's thesis at Virginia Tech on "Spiders of alfalfa with notes on the biology of *Tetragnatha laboriosa* Hentz" (Howell, 1969). With his advisor Robert L. Pienkowski, he wrote the classic paper in the Journal of Economic Entomology, "Spider populations in alfalfa, with notes on spider prey and effect of harvest" (Howell & Pienkowski, 1971). The introduction in this paper is credited with showing that experimental studies of spiders in American agriculture were mostly absent at that time (Bell, 2005). The study itself used a D-Vac® to sample the litter and upper soil and 500-sweeps of a 15-in diameter net to take spiders on the alfalfa at one-week intervals during the warm months (monthly during the colder months) from March 1967 to June 1968. Several samples were taken at three-hour intervals during a twenty-four hour period to assess time of day on sampling efficiency. Temperature and humidity readings were taken. Over 4,000 spiders in 15 families and 124 species were collected. The attention to environment, season, and time of day effects, scope of the sampling, and addition of laboratory feeding tests to address what the spiders were actually eating in the alfalfa mark this paper as one of the most thorough of the early studies of spiders in crop fields.

In an example of the observational approach to studying spiders, Laura Elsa Sabath collected an individual *Gea heptagon* from her web in a lawn in Portsmouth, Virginia, put her into a terrarium, and observed the spider until she died (Sabath, 1969). Sabath's motivation was to study a spider that was not currently being used by other experimenters, and one that, although widespread, had not been studied extensively. She made observations on rapid change of the spider's color after it fell to the ground when disturbed, web spinning, feeding, the egg sac, and spiderlings.

J. P. McCaffrey and R. L. Horsburgh of Virginia Tech's Shenandoah Valley Research Station studied spiders in Virginia apple orchards and used limb beating as a sampling method for collecting spiders on apple trees. They documented that the proportions of hunting spiders in current vs. abandoned orchards were similar in most cases. The spider species exhibited niche separation on different parts of the trees; the authors thought that this might facilitate suppression of insect pests (McCaffrey & Horsburgh, 1980). Another study evaluated time of day and season as factors in sampling results using limb beating. *Clubiona* spp., which are nocturnal, were captured significantly more often at 0300 h, while salticids and total spiders were collected more during 0900 and 1800 h. Limb beating was deemed a satisfactory method for collecting both web-building and hunting spiders, but spiderlings of some (*Philodromus*) were not captured efficiently by this method (McCaffrey et al., 1984).

C. L. Steitenroth (with Norm Horner at Midwestern

State University) published an account of 18 genera and 30 species of jumping spiders of the Virginia Peninsula (Steitenroth & Horner, 1987). The study produced records of five species new to the state.

William A. Shear of Hampden-Sydney College has published more than 200 papers and book chapters, primarily relating to classification and evolution of arthropods, and is the co-author or editor of two books, including *Spiders: Webs, Behavior and Evolution* (Shear, 1986). His paleontological studies began in 1980; more recently he returned to taxonomy and to a new direction in ecological chemistry. He has published notes in *Banisteria* on a leptonetid and a pholcid new to Virginia (Shear, 2007; Clark & Shear, 2010) and was chief scientific consultant, script editor, and on-camera participant for the film, "Ultimate Guide: Spiders," broadcast on 9 July 2001 on the Discovery Channel.

A paper published by Shear and colleagues on a fossil spider from New York extended the fossil record of non-araneomorph spiders back to the Devonian (Selden et al., 1991). A later paper including a fossil Virginia spider from the Triassic was published by Nicholas C. Fraser of the VMNH and co-workers (Selden et al., 1999). These specimens represented the oldest known fossil araneomorph spiders and extended the fossil record of that group back significantly. Shear and colleagues also published papers on fossil evidence of the origin of spider spinnerets, which are considered the defining adaptation of spiders (Shear, 1989; Selden et al., 2008). In the 2008 study, fossil evidence was combined with developmental genetic studies to clarify how use of silk may have evolved in spiders.

Brent Opell's research at Virginia Tech is an example of the modern experimental, quantitative approach to studying spiders. Early studies of Virginia *Hyptiotes* (Uloboridae), for example, showed that web production of early instars is independent of container size (Opell, 1982). Opell also has published a revision and a checklist of American Uloboridae (Opell, 1979; 1983). His research currently focuses on spider systematics and integrative biology using morphological and molecular characters and phylogeography (Opell Lab, 2009). These studies have produced numerous papers on the viscous capture threads of orb weavers (e.g., Opell & Hendricks, 2009). These and other studies on spider morphology, behavior, genetics, and evolution (e.g., Opell, 1984, 1990, 1998, 2010; Opell & Bond 2001; Opell et al., 2007) are of broad interest to spider systematists and ecologists.

Michael W. Beck and Edward F. Connor of the University of Virginia and Blandy Experimental Farm conducted a study examining the importance of covariance in traits related to foraging, between developmental stages of the crab spider *Misumenoides formosipes* (Beck & Connor, 1992). They found that prereproductive weight and fecundity were highly correlated to carapace width. Growth of spiders fed *ad libitum* in the laboratory was unrelated to size, which suggested that size in the field was related to prey-capture success. Small females (measured by carapace width) did not reproduce, although they constituted a significant proportion of the population. The authors emphasized examining stage-specific constraints in order to understand the effects of foraging on reproductive success.

While at Virginia Commonwealth University, Stephen R. Johnson studied spiders of early successional stages of a barrier island (Hog Island) that is part of the Virginia Coast Reserve. He found that spider diversity and density differed more between sites than between shrub species (*Baccharis halmifolia* and *Myrica cerifera*) (Johnson, 1996).

Steven M. Roble of the Virginia Department of Conservation and Recreation's Division of Natural Heritage recorded a range extension to Virginia for *Gasteracantha cancriformis* (Roble, 1994). Roble often collaborated with Richard Hoffman, co-authoring several papers on spiders (and other taxa) new to the Virginia fauna (Hoffman & Roble, 2012 [three wolf spiders]; Roble & Hoffman, 2012 [*Drassyllus rufulus*]).

The author of this paper published a preliminary list of the spiders of the Great Dismal Swamp (Abraham, 2000), as well as a list of the spiders found during the Potomac Gorge Bioblitz (Abraham, 2008). Although other faunal lists for the Great Dismal Swamp date from much earlier, Abraham's list is the first for the spiders of the Swamp. The list includes 14 families, 43 genera, and 56 species. Likewise, the list of Potomac Gorge spiders, albeit incomplete, is the first specific to that area (although many spiders had previously been collected in and around the Washington, D.C. area). The Potomac Gorge Bioblitz list included 37 species in 29 genera and 12 families.

Anne Danielson-Francois, Christine A. Fetterer, and Peter D. Smallwood (the latter two authors are from the University of Richmond) published a paper on body condition and mate choice in *Tetragnatha elongata* (Danielson-Francois et al., 2002). They found that males preferred longer, heavier females with higher body condition. This study may have been the first to show the influence of body condition on mate choice in spiders. Smallwood had previously published a study on web site tenancy in this species that challenged a model of risk-sensitive foraging and emphasized the importance of considering multiple scales in ecology (Smallwood, 1993).

Rachel E. Mallis and Lawrence E. Hurd at Washington and Lee University studied ground-

dwelling spider assemblages in the Science Park at their institution with pitfall traps (Mallis & Hurd, 2005). They collected 50 species from six sites, but found no correlation between spider assemblages and successional stage of the habitat. They thought that spider community composition is generally unpredictable, due to stochastic colonization and specific resource requirements following immigration.

While at the University of Virginia, Lily Ahrens and Johanna M. Kraus (Kraus is now at Washington and Lee University) reported on wolf spider movements along a pond edge at Mountain Lake Biological Station, near Pembroke, Virginia using mark-recapture. In contrast to previous studies, in this study wolf spiders (*Pardosa* spp.) moved little in time or space, although the short-term (summer) and small spatial scale (meters) of this study may have had an impact (Ahrens & Kraus, 2006).

At the 2008 Virginia Academy of Science meetings, Marc A. Milne, then a graduate student of Deborah Waller at Old Dominion University, presented on nectar feeding by spiders of three families: Linyphiidae, Lycosidae, and Agelenidae. His dissertation concerned spiders associated with the purple pitcher plant (*Sarracenia purpurea*) in Virginia and North Carolina (Milne, 2010). From this research he published a paper on the purple pitcher plant as a spider oviposition site (Milne, 2012).

Already in 1990, the lack of support for taxonomic arachnology was lamented (Coddington et al., 1990). The situation is not as dire for spiders as for other arachnid groups, but few young scientists enter the field due to a lack of open, funded positions (Coddington et al., 1990). There is yet much remaining to be discovered about spiders in Virginia, as well as the rest of the world, in 2013, and conservation of these important predators is not well served by the lack of information. Virginia is lucky to have the VMNH, the Division of Natural Heritage, and the extant individuals mentioned above to carry on the study of the state's spiders, but new recruits and funding are necessary if complete information on the presence and distribution of spiders in Virginia is to be obtained.

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A Brief History of Terrestrial Game Species Management in Virginia: 1900 – Present

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ABSTRACT

Terrestrial wildlife management in Virginia has evolved from a process that condoned the unwarranted elimination of native top predators a century ago to the research-vetted management practices employed today. In this paper, we focus on the evolution of the state game department and changing roles of the individuals who work toward sound game management. We address major national and state laws that have impacted wildlife management, discuss the changing role of game wardens, and introduce the leading characters in the Commonwealth who have battled for stronger, proactive game management laws. The changing needs and interests of the public – mainly a shift from consumptive to non-consumptive wildlife use – also have impacted the way Virginia wildlife has been managed. We follow a decade-by-decade approach as we highlight the historical development of terrestrial game management in the Commonwealth.

Key words: Game Commission, game species, game wardens, Virginia Department of Game and Inland Fisheries, wildlife management.

INTRODUCTION

Nearly a century has elapsed since the inception of a game management agency in Virginia. Over the last 50 years, multiple attempts have been made to summarize this history, ranging from a 342-page dissertation (Reeves, 1960) to magazine articles for the general public (e.g., White, 1976). Many such publications are either out-of-print or generally inaccessible to those with an interest in the history of wildlife management in the Commonwealth. In this paper, we summarize the information and narratives in these publications and interagency reports. In doing so, we describe the humble beginnings of terrestrial game management in Virginia and follow its advancement through the past century.

THE EARLY YEARS: 1900 TO 1919

Since the founding of Virginia in 1788, wildlife game species have been a source of sustenance, as well as sport, for natives and visitors. At its founding, reports of abundant game species were not uncommon. By the early 1900s, game species once used for subsistence living, such as the white-tailed deer (*Odocoileus virginianus*), black bear (*Ursus americanus*), eastern cottontail (*Sylvilagus floridanus*) and northern bobwhite (*Colinus virginianus*), were perilously close to regional extirpation (Gooch, 2001). Commercial hunting and over-harvesting went hand-in-hand.

Observing this dramatic decline in once-common game species, non-commercial hunters of the early 20th century became the first conservationists. On the national stage, they worked with politicians to pass the Lacey Act. Passed into law on 25 May 1900, the act focused on two main issues: trade of illegally harvested game and non-game and the protection of native birds. The latter issue was addressed by limiting the number of exotic birds introduced, banning some trade of bird feathers, and protecting both game and non-game birds (Anderson, 1995). This law was an important start to conservation and preservation, but did not address many game issues in Virginia.

No state game laws existed in the Commonwealth of Virginia until 1910, when the General Assembly

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passed several minor laws for the protection of game, but these were merely stopgap measures (Anderson, 1995; Gooch, 2001). For example, laws provided a closed season on a few game species trapped for profit: muskrat (*Ondatra zibethicus*), American mink (*Neovison vison*), northern river otter (*Lontra canadensis*), raccoon (*Procyon lotor*), and gray fox (*Urocyon cinereoargenteus*). However, these seasonal limitations were restricted to a few counties where numbers were clearly in decline and there was an environmental authoritative presence to enforce game laws (Hart, 1923). Still lacking were comprehensive state-wide laws and adequate enforcement capabilities on a large scale.

By 1912, sportsmen in Virginia were urging the creation of a state game department to provide protection for harvested wildlife. However, members of the General Assembly were reluctant to give wildlife management its own official department. Instead, they passed more protective acts for (fish and) terrestrial game species, this time on a statewide level (Hart, 1923). There was an emergency closure of the small game and wild turkey (*Meleagris gallopavo*) season due to heavy snows from mid-January until 2 February 1912. Although it is unclear how the General Assembly went about closing a season, the board of supervisors of any county had the right to immediately terminate the season of any game animal given sufficient reason, such as snow or other extraordinary weather. Upon closing, the county board was to immediately post the decision in the nearest town newspaper and send a certified copy of the notice to local authorities (Tyus, 1924).

On 17 June 1916, the Virginia Department of Game and Inland Fisheries (VDGIF) was created under the supervision of the Commission of Fisheries (est. 1875). The charge of this new department was to manage, conserve, and protect the wildlife of Virginia. The fisheries commissioner, John S. Parsons, doubled as the commissioner for this new department for two years until his death in 1918. The first Chief Clerk for the game department was M. D. Hart, a man of "tremendous foresight and enthusiastic drive" (Reeves, 1960). With the help of just two other individuals and an office in the cloak room of the Senate Chamber of the state capitol (VDGIF, 1917), Hart had before him the daunting task of developing an entire game agency. Hart visited well-established game agencies in New York, New Jersey, and Pennsylvania, looking to these agencies as sources of inspiration, knowledge, and logistics about the inner workings of such an office (VDGIF, 1917; Reeves, 1960).

The department received a modest startup loan for assistance during its first year from the state budget. Subsequently, it was funded entirely by the sale of hunting licenses, with no assistance from the state budget. Up until that point, hunting had been considered the right of every person in the state with no fees or bag limits. Now, knowledge of these new rules and regulations needed to be disseminated to the general public and new permits and licenses enforced. Wardens were hired for every county in the Commonwealth from a list of "suitable persons" selected and delivered by the town councils. Such willing individuals were provided "with badges, copies of the game laws, application blanks for hunters' licenses, notices to hunters to be posted in their counties, and … advised to travel their territories as much as possible (VDGIF, 1917)." Game wardens earned a salary of $50-60 per month and were expected to supervise their territories and apprehend and fine offenders (Hart, 1923; Lemmert, 2003).

License fees varied in 1916: county hunting licenses were $1 each, state licenses $3, and non-resident permits were $10 (Hart, 1923; Lemmert, 2003). In its first annual report (1917), the VDGIF applauded its own sales of hunting licenses (over $88,000), taking in substantially more revenue than anticipated (VDGIF, 1917; Hart, 1923). Using this income, plans for restocking of species were developed and implemented. For example, the department imported and stocked 150 elk (*Cervus elaphus*) in the mountainous terrain of western Virginia (albeit a failed effort), and stocked thousands of English ring-necked pheasant (*Phasianus colchicus*) eggs and individuals throughout the state (VDGIF, 1917; Hackman, 1976).

By 1919, game wardens expressed discontent, because their duties increased with no financial compensation. Specifically, the Baker Dog Law was passed that year by the state legislature, requiring wardens to license dogs in their jurisdiction, with all of the income going to the counties of residence. Presumably, those dogs that were not claimed by owners or were feral were destroyed. Through 1922, a reported "25,892 worthless dogs" were euthanized (Hart, 1923). Given this substantial increase in workload, many wardens resigned. In 1920, the Baker Dog Law was amended to give 15% of the license fees to the department to compensate for the extra work expected of them and reestablishing the goodwill of game wardens (Hart, 1923).

1920s

At the beginning of the department's second decade, most predators were considered nuisance species and a threat to terrestrial game animals. Therefore, predators were hunted to boost the game numbers available to

hunters for subsistence and sport. In 1921, the Virginia Game and Fish Protective Association hosted a hawk-killing contest with $250 in prizes (Anonymous, 1921a). While there was "some" justification that "some" predators were harming game populations in the 1920s, these predators were mostly introduced (Anonymous, 1921b). Burton (1937) reported that a single feral cat *(Felis catus)* killed 58 birds in one year and advocated for the control and removal of this nuisance species. The feral cat debate continues today and has yet to be resolved.

Despite the misdirected and uninformed attitudes and actions towards predators at that time, the department was making progress in the restoration of other game species. They established regulated hunting seasons and more stringent law enforcement for game, including ring-necked pheasants, wild turkey, and northern bobwhite (VDGIF, 1917). Such controls were essential for species that were nearly extirpated. For example, white-tailed deer harvests in the 1920s were estimated at less than 800 individuals annually (Gooch, 2001).

The department employed public-friendly tactics to promote knowledge of new game laws, including a bulletin called *Game and Fish Conservationist*. This publication, printed by the department, served to proclaim examples for sportsmen and conservationists, publishing such innovative topics as fish ladders for dams as early as 1922 (DeLaBarre, 1937b). Positive stories were emphasized in the bulletin, like the role female game wardens were playing in halting the trade in illegal game. For example, in 1923, *Game and Fish Conservationist* published images of Mrs. B. M. Miller and Mrs. C. E. Sykes, who were employed as game wardens in the second district, based out of Norfolk. "These efficient wardens, through surveillance of markets and trains, kept 'bootlegging' of game and fish at a minimum" (Lee, 1922; Layne, 1923). This action displayed the foresight and willingness of the department to employ a variety of persons and tactics to successfully enforce their regulations.

In 1924, Virginia's first statewide game law ended county-specific hunting seasons. The Virginia Senate, in Bill #141, set into law a statewide hunting season from 15 November to 31 January (Tyus, 1924). White-tailed deer limits were stringent, limiting take to antlered bucks: one per day and two per season. This new law also required non-resident hunters to purchase a license. The first fishing licenses, available for purchase as a bundled package with hunting and trapping permits, were issued that same year (Tyus, 1924; Gooch, 2001).

In 1926, after a decade of operating under the supervision of the Virginia Fisheries Commission, the Department of Game and Inland Fisheries was granted freedom to self-govern and was no longer controlled by a separate government entity. A name change was included with this new governance. The Virginia Department of Game and Inland Fisheries became the Virginia Commission of Game and Inland Fisheries. Throughout the rest of the 1920s, the Commission, under the direction of W. McDonald Lee (1922–1926), Harry R. Houston (1926), and A. Willis Robertson (1926–1933), focused on restocking game species that had been hunted to near extinction: white-tailed deer, black bear, and wild turkey. For example, in 1929, 150 wild turkeys were purchased for $20 each for captive breeding and restocking in their prime habitat throughout the state (Gooch, 2001).

1930s

New game programs were sluggish throughout the 1930s, in line with a depressed national economy (Hackman, 1976). However, restocked game species from the 1920s were beginning to show signs of visible recoveries. In response to the turkey stocking programs at the end of the last decade, members of the Virginia Cooperative Wildlife Research Unit at Virginia Polytechnic Institute initiated a population study of this species in 1938. Sixty-nine counties now contained wild turkey populations, a dramatic increase in less than a decade (Gooch, 2001). With the State Game Farm also raising wild turkeys (322 individuals reported for the early 1930s) and bobwhite quail (3,349 individuals reported), presumably for release, efforts to recover these game birds continued in full force (Stras, 1949a).

At the federal level, bills were passed in the 1930s that affected wildlife management within the Commonwealth and throughout the United States. The Migratory Bird Hunting Stamp Act of 1934 collected funds to support duck management. Specifically, income was directed towards land purchases for the National Wildlife Refuge system. This land would provide suitable nesting habitat for duck repopulation efforts and terrestrial game species that could make use of these substantial tracts of land and wetlands. Also at a national level, Big Levels Wildlife Management Area in Augusta County was signed over to the U.S. Forest Service in 1935 for experimental wildlife management projects (Stras, 1949b; Gooch, 2001).

Perhaps the most important step toward wildlife restoration and conservation was accomplished in 1937 with the passage of the Federal Aid in Wildlife Restoration Act. Virginia Congressman (and former state game commissioner) A. Willis Robertson and Senator Key Pittman from Nevada co-sponsored the bill to divert an existing 10% excise tax on sporting

firearms and ammunition to the states for wildlife restoration and management efforts. Although the act has been amended several times since 1937, its main elements have remained intact (Stras, 1949b; Gooch, 2001). This tax is used to provide funding to state game and wildlife programs that promote conservation and education.

Educational efforts were also increasing. In 1937, *Virginia Wildlife* was first published as a bulletin of the Virginia Wildlife Federation and the Virginia Wildlife Conservation Education Council in Blacksburg. It replaced *Game and Fish Conservationist*, which had been canceled in 1931 due to the depressed economy (DeLaBarre, 1937b; Gooch, 2001). Like its predecessor, *Virginia Wildlife* was intended to educate the public on wildlife conservation and to encourage active cooperation in game management. The inaugural issue championed the efforts of the Game Commission, which included the reintroduction of white-tailed deer, the abolition of predator bounties, and wildlife education in schools. It also referenced the passage of the Federal Aid in Wildlife Restoration Act that year, stating, "The clouds ahead are lifting; wildlife now has a chance" (DeLaBarre, 1937a). Except for a 4-year hiatus during war time (1942-1946; Patton, 1946), this magazine has continued to educate the public to the present day.

1940s

By the mid-1940s, it was clear that the restocking efforts and land acquisitions of the 1920s and 1930s were having a positive impact on multiple terrestrial game species. Hunter harvests presumably increased, but a statewide monitoring system was lacking. Thus, with the greater use of the land and its resources for hunting and recreation, the Commission implemented more intensive supervision of the wild lands. In 1947, the Commission created a statewide checking station system. Hunters now had to tag their game at a local check station, where sex, age, and other basic information were recorded on each animal. This system allowed for authorities to be better informed about hunter harvests and to adjust seasons accordingly based on population estimates (Gooch, 2001).

The take of white-tailed deer in 1947 was 4,000 individuals, as recorded by the new check stations. An accurate count of black bear harvest (163) also was reported for the first time. Although wild turkeys were still a rarity, Carl Nolting, game commission chairman from 1933 to 1942, estimated that there were ca. 25,000 individuals in the Commonwealth (Gooch, 2001). An American beaver (*Castor canadensis*) restoration program also was enacted in the late 1940s, as this species had been nearly extirpated from overharvesting practices by the fur trade industry (Stras, 1949b; Hackman, 1976; Gooch, 2001).

In the post-Great Depression era, new programs began to spring up. For example, VDGIF appointed a Director of Education in 1949. This followed the 1948 Wildlife Restoration Program established by the Commission, which placed a greater emphasis on public education. The new Education Director established several goals to inform the general public about wildlife management. In addition to providing informational bulletins and pamphlets about game and fish species for use in public schools, the commission turned to films, radio broadcasts, and television shows for educational outreach. Around the same time, the Commission teamed up with the Virginia Department of Education to teach conservation courses at colleges, thus providing future teachers with the skills and knowledge to educate what could be considered the first generation of wildlife managers (Anonymous, 1949).

1950s

In the 1950s, a beneficial shift in habitat management style became evident. Nearly gone were the days of importing farm-grown, pen-raised, or wild-caught individuals from outside of the Commonwealth (Hackman, 1976). While wild turkeys were still being introduced into new counties, the source of the individuals was now in-state. For example, Gooch (2001) described the trapping efforts of wild turkeys from the Gathright Wildlife Management Refuge (Bath County), where turkey populations were thriving, into depleted areas to the east. As stocking efforts declined, a shift in the management paradigm was evident.

Instead of constant stocking, the goal became habitat management or improvement, an attitude embraced in the late 1940s and implemented in the 1950s (Stras, 1949b). Terrestrial game species were now a "crop" that could be managed in a sustainable fashion (Stras, 1949b). Such crops included wild turkeys, white-tailed deer, bobwhite quail, and American beavers. A victory of sorts was celebrated when the first American beaver trapping season opened in 1953; this nearly extirpated species was once again thriving (Hackman, 1976).

By the late 1950s, there were 607,287 ha of National Forest land in Virginia, 600,000 sportsmen, and just 138 game wardens to supervise them all (Gooch, 2001). More refuges were purchased, including Hog Island Waterfowl Refuge (1951; Hackman, 1976), Gathright Wildlife Management Refuge (1957; source of the wild turkeys), and Saxis Waterfowl Refuge (1957; Gooch, 2001). These new territories required

constant monitoring to maintain the integrity of the refuges for their intended purposes. On a related note, while the duties of game wardens were constantly increasing, acknowledgement of their efforts also increased. In 1959, VDGIF created the "Game Warden of the Year" award for those individuals that far exceeded the minimal requirements of the job and showed true dedication to their work (Hackman, 1976; Gooch, 2001).

1960s

The 1960s also saw contradictory healing and exploitation of game. Northern bobwhites were harvested in excess of 1.4 million birds during the 1965-1966 hunting season; demand was high, despite the acknowledgement that the population was in decline. Similarly, eastern cottontails were on a steep decline for reasons that could not be explained at the time. Although wild turkey harvests averaged just 280 individuals, the presence of any harvest was considered a success. White-tailed deer continued to recover, with harvests averaging 25,000 individuals per year (Gooch, 2001).

Habitat management techniques first implemented in the 1950s continued to evolve and improve. No longer were high-effort bulldozing and subsequent seeding efforts utilized to create or maintain early successional habitats for quail, eastern cottontails, and other game species. Instead, techniques were becoming more fine-tuned and less labor-intensive. The same bulldozed habitats could now be maintained by the time-efficient occasional prescribed burn, or small-scale, selective tree removal (Hackman, 1976).

The education efforts directed towards hunters were also changing. In 1961, hunter safety training classes were established with the goal of training every hunter in the basics of gun safety and ethical treatment of game. White (1976) reported that these classes educated over 167,000 Virginians in the first 15 years of operation.

1970s

By the early 1970s, game numbers had rebounded to allow for hunting harvests that rivaled pre-Civil War abundance. The white-tailed deer harvest was close to 50,000 individuals annually and wild turkey populations had recovered to the point where harvests reached 2,500 individuals/year (Gooch, 2001). Northern bobwhite harvests peaked in 1970 at approximately 1.5 million birds (Norman & Puckett, 2008). Black bear populations also were increasing, with the harvest reaching nearly 300 individuals in 1971 (Gooch, 2001; Klenzendorf, 2002). At that time, the state population of bears was estimated at 1,660 individuals, up from <1,000 in 1951 (Gooch, 2001).

Although the cost of maintaining or restoring game species increased, the cost of licenses had stayed much the same since 1916. Chester F. Phelps, director of the Commission from 1958-1978, saw an impending funding crisis and opted to increase the cost of licenses. These newly collected fees supported the active management of almost 800,000 ha of land. Commission staff drew from many resources to manage these lands for public enjoyment and enforce hunting regulations (Stras, 1949b; Gooch, 2001). Game wardens continued to be an important resource. In addition to patrolling for poachers, they were charged to contain illegal tree harvesting and to survey rugged and mountainous terrain. In the line of duty, through 1972, eight game wardens lost their lives. Causes were anthropogenic, and individuals with a blatant disregard for the law and the hunted animals were the guilty parties (Gooch, 2001; Eliason, 2011).

1980s

As further proof that wildlife managers were performing their duties with dedication and determination, some species had become so abundant that their seasonal bag limits were increased statewide. For example, during the 1985-1986 seasons, VDGIF increased bag limits for white-tailed deer from two to three. With an increase in hunting and therefore warden responsibilities, game wardens needed more authority to ensure that they could perform their jobs adequately. In 1982, wardens were granted general law enforcement powers, the same as local and state police officers (Randolph, 1996; Gooch, 2001).

Although hunting licenses were still a reliable source of funds for the agency, VDGIF reached out to an alternate source of funding. In 1982, taxpayers had the option to donate their tax refunds directly to the non-game division of VDGIF. A checkbox on the state tax form allowed them to donate some or all of their returns to non-game conservation. The program netted over $350,000 in its first year, and donations peaked at $752,840 by 1987. These funds assisted with programs in parks and conservation that were not currently funded by the Pittman-Robertson Act (Gooch, 2001; U.S. Fish and Wildlife Service, 2012).

During this time, lawmakers also set safety as a priority. Blaze orange became mandatory for white-tailed deer hunters in 1987. By 1988, hunter education courses were required prior to purchasing a license. This thinking was no doubt beneficial for wildlife as well, as more educated hunters would wait for a more

humane kill and be more knowledgeable about their ethical limits and ranges of fire (Gooch, 2001).

The Commission of Game and Inland Fisheries again experienced a name change in 1987. In a move that was purely administrative, the Commission returned to its original title, the Virginia Department of Game and Inland Fisheries (VDGIF; V. Shepherd, pers. comm.).

1990s

By the 1990s, outdoorsmen spent over $2 billion annually on Virginia wildlife recreation. This group included not only hunters and fishermen, but also non-consumptive users such as birdwatchers, kayakers, hikers, bikers, cavers, and other outdoor enthusiasts. Some species of wildlife were flourishing under the new attention and adapting rapidly to urban settings. White-tailed deer had increased to such an extent that some limitless tags were sold to reign in populations and curtail damage to crops and ornamental gardens (Gooch, 2001). Black bear populations were estimated around 3,000 to 3,500 in 1993, with 600 or more bears harvested per year by the mid-to-late 1990s. Several seasons for bears were implemented, including two archery seasons that overlap with a gun season. Seasons with and without dogs also were introduced. This strong interest in bears has led to stricter bag limits on this species (Pelton, 1999; Gooch, 2001).

Despite these advances in black bear and white-tailed deer management, not all species were thriving with human intervention and hunting. Harvest reports for the northern bobwhite, historically exceeding 1.5 million, had declined to 160,000 individuals by 1997. The reasons for their disappearance were tied to the replacement of early successional habitat by later successional stages in the last century. As bobwhite became harder to harvest, the desire to hunt them declined precipitously. Because game management often follows a supply-and-demand relationship, successful bobwhite management suggests that densities need not return to historic levels to meet the needs of today's hunters (Penhollow & Stauffer, 2000; Gooch, 2001).

2000 TO PRESENT

Current VDGIF Executive Director, Robert Duncan, stated, "Today, our problem is more one of managing our rich wildlife resources than trying to increase our numbers" (Gooch, 2001). Indeed, many species-specific management plans emphasize maintaining populations rather than expanding them. This is the case for white-tailed deer (VDGIF, 2007), which have been harvested in record numbers over the last decade (e.g., 222,074 in 2010 and 231,454 in 2011; Thompson, 2012). The estimated statewide black bear population was nearly 5,000 in 2001, with continued increases expected (Gooch, 2001). Black bear harvests reached record highs, with 2,221 taken in 2010 and 1,997 in 2011 (Thompson, 2012).

Although wild turkey densities and harvests are variable across the Commonwealth, the statewide population was estimated at 150,000 individuals by 2010. Harvests for turkeys were reported at 3,470 in 2011 and 2,678 in 2010 (Norman, 2008; Thompson, 2012).

Only a few game species, including bobwhite quail and elk, are currently being managed for marked increases in the next decade. Despite a 92% decline in the number of bobwhite licenses sold (since 1970), VDGIF is looking to recover early successional habitats and educate the public about the importance of quail to hunters (Norman & Puckett, 2008). The success of this educational push is uncertain: in 2005, 66,384 bobwhite were harvested, and this harvest has continued to decline. Just 40,782 bobwhite were taken in 2010 (VDGIF, 2012). The reintroduction of elk in March 2012 into Buchanan County follows successful management efforts in neighboring Kentucky (VDGIF, 2010; A. Boynton, pers. comm.). As elk migrated into the Commonwealth from Kentucky, pressure mounted for VDGIF to initiate its own reintroduction process. If the growth of Kentucky's elk population (1,555 introduced in 1998; >10,000 in 2012; A. Boynton, pers. comm.) is any indication of future success in Virginia, this once-extirpated ungulate may become a commonly hunted species in future years.

In response to new federal mandates regarding funding eligibility for state wildlife grants, a Virginia wildlife action plan (WAP) was developed in recent years. The ultimate goal of the WAP was "to identify key species and habitats in need of conservation and to prioritize actions and research needs for future statewide conservation activities for all interested Virginians" (VDGIF, 2005). The WAP includes management of both game and non-game species and efforts are prioritized according to Virginia's physiographic regions. By 2001, VDGIF managed more than 35 wildlife management areas covering 80,971 ha.

CONCLUSION

VDGIF's shift from strictly game species management to a focus on non-game species, public education, land management, and conservation is not a new one. In light of public attitudes shifting from consumptive wildlife uses (hunting, fishing) to

primarily non-consumptive uses (birdwatching, recreational boating, hiking, and biking), the direction of the agency is constantly adapting to the needs of the wildlife species and the public. This trend is evident by the number of hunting licenses sold in 2010 (245,185), which is approximately half that for 1974. In recent years, a 1-3% annual decline in license sales is not uncommon for Virginia and neighboring states (Greene, 2011).

Nearly a century ago, VDGIF was an agency in its infancy, entirely dependent upon license sales to finance their management initiatives. Today, other avenues of funding are available, although license sales still constitute 38% of the 2011 budget (VDGIF, 2011). This shift away from hunting has caused the agency to reassess its goals, budget allocations, and management directions. As VDGIF nears its centennial in 2016, its current strategic plan emphasizes the need to reconnect the public with the wildlife around them. Although much has changed since 1916, some goals and attitudes remain the same:

> "With continued protection and proper restrictions on hunting seasons, quail, [ruffed] grouse [(*Bonasa umbellus*)] in the western part of the State, and even deer and wild turkey in many localities will again become plentiful as a result of their natural increase in the open, the climate of Virginia making her fields and forests the ideal habitat of all of these."
>
> First annual report of the Department of Game and Inland Fisheries of Virginia: ending June 30, 1917.

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Nature, Natural History, and Naturalists in Virginia Since 1927: A Personal Evaluation[1]

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INTRODUCTION

Most primitive societies – unless surviving on the very cusp of starvation – normally continued to support those members too old to hunt, fight, gather, harvest or bear children to serve as custodians of tribal tradition and regulations, passing unwritten knowledge through generations like members of a relay team. In effect, they were the first historians. Only in that context can I justify the presumption of exposing you tonight to a highly subjective, and often very biased, recitation of some of the events and trends affecting the general subject of natural history in Virginia from a fairly brief, and relatively recent, period in the history of this Commonwealth as seen by one who was there when it happened, and yes, often even *before* most of it happened. I wish to touch on three aspects of the subject which can be treated separately even though they are difficult to define and broadly overlap.

I. "NATURE" AS ENVIRONMENT

This emotionally charged word has a panoply of meanings: all reflecting the different ways in which individuals, interest groups, or entire societies perceive their relationship to everything outside themselves. Many would argue to include the entire Universe as a part of Nature, others would be more comfortable to embrace only those objects or phenomena peculiar to the planet we inhabit, both causing and resulting from the processes in operation since the origin of the Earth. This would essentially be the *physical environment and the organisms which populate it*. One problem is whether to include Mankind as a part of Nature. Many current definitions distinguish between a "natural world" and another "unnatural world" represented by the impacts of *Homo sapiens*. My personal preference would exclude the influences generated by the Ultimate Invasive Species over the past several millennia, when we changed from being merely existing in primitive ecosystems to drastically affecting them. Pragmatically, I realize that a history of the natural environment in Virginia must take into account the mostly negative impacts that this single recent factor has imposed.

First the good news:

A look at the positive results of recent human response to environmental degradation during the past 80 years shows substantial improvement. It is easy to forget that basically ALL of the state and federal regulatory agencies such as EPA, DEQ, and DCR did not exist in 1940, nor did the federal Wilderness Act, Wild & Scenic Rivers Act, Environmental Impact requirements, and Endangered Species legislation.

Water quality: In my childhood (early 1930s and 1940s) many rivers in Virginia downstream of paper mills ran as black as ink, malodorous and totally abiotic. At the same time, small cities through the state had no pretense at sewage treatment, the final effluent of the system simply discharging directly into the nearest river. Under pressure by the EPA, sources of such pollution, as well as of mercury and kepone, cleaned up their act, and the affected streams have largely recovered much of their original quality, although many important faunal elements have never returned.

Forest cover: The US Forest Service has progressed from an adjunct of the timber industry to a practitioner of multipurpose management that in addition to providing for watershed protection, limited timber harvest, and outdoor recreation has set aside extensive wilderness areas and special use tracts that simply

[1]Concluding remarks presented at the Virginia Natural History Society's symposium "Historical Explorations into Virginia's Natural History" held on 26 September 2009 at the Virginia Museum of Natural History in Martinsville.

[2]Deceased 10 June 2012.

protect enclaves of reasonably pristine Nature "for future generations". With protection against fire and logging, even our decimated stands of red spruce are recovering, although against the future spectre of ever warmer climate.

Drowned streams: The last major impoundments of Virginia rivers (Philpott, Smith Mountain, Buggs Island, Claytor, Gathright, and Anna lakes) were completed during the 1950s, before anybody knew or cared what would be inundated in the process. Since then it has been discovered that the US Army Corps of Engineers and power companies are *not* omnipotent, and that the Corps can be defeated or managed. The Gathright project was strongly but unsuccessfully resisted by environmental groups, including the VDGIF, but since then I have seen proposed impoundments on the New, Smith, and Pamunkey rivers overruled with the aid of strong local opposition. Dams are even being removed, restoring free flow from source to mouth (e.g., the Rappahannock River).

Land protection: The Nature Conservancy in Virginia, an infant of about five staff members when I first knew it, has grown along with its parent organization to an agency of great influence and accomplishment in the acquisition and management of large, usually jeopardized tracts, with such notable successes as the Great Dismal Swamp, the Eastern Shore barrier islands, and both Clinch and Warm Springs mountains. On a smaller but equally impressive scale, the Virginia Department of Conservation and Recreation has developed in just 20 years a network of 59 Natural Area Preserves protecting areas of special interest. In addition to these state and federal initiatives, the private sector has, also within the past two decades, initiated a spectrum of vigorous land easement programs by which privately owned property is guaranteed exemption from future development. Local advocate groups, like Friends of Dragon Run or the Bull Run Mountains Conservancy, play an increasing role in protection initiatives. Although collectively including less than 10% of the state's land surface, these various conservation measures represent successful environmental efforts that would not have been imagined 40 or 50 years ago. In this context, then, the local biotas in scores of refuges can expect a measure of permanent security. Even Virginia's cave systems have come under this new umbrella.

The Down Side:

Although stringent regulations against chronic stream pollution are in place, we are still having occasional chemical or wastewater spills: failure of wastewater catch basins and overturned tanker trucks. While these are "accidents" they still have dreadful effects on aquatic life. I recall vividly the Carbo spills of 1967 and 1970 that sterilized many miles of the Clinch River, and another farther upstream in August 1998. Acidification of streams by mine drainage is still a problem affecting the Powell and Big Sandy drainage basins.

Since organisms are a major part of any environment, Virginia has seen its share of bad developments, under the category "invasive species". The gypsy moth in particular has had a serious impact on broadleaf forests, defoliating oaks across much of northern and western Virginia, repeated infestations causing tree death. Control measures have so far shown limited effectiveness although continued spread southward may be retarded by climatic and microbial factors. Although the hemlock adelgid appears to have decimated these trees in some parts of Virginia, other extensive stands have so far avoided, or resisted, infestation. The jury is still out on the case of balsam adelgids at Mount Rogers.

Despite intervention by a number of cooperating agencies, the loss of unionid mussels in Virginia seems to be chronic and ongoing. Of the approximately 60 species recorded for the Clinch River by Ortmann in 1918, only about 40 remain, a loss of one-third of the original fauna. The unionids of the entire Shenandoah River system in Virginia have apparently been, with one exception, extirpated during the past half-century. I have noted declines in both numbers and diversity in several Virginia streams since 1988. Despite successes in rescuing individual species like bison, whooping cranes, and California condors, I very much doubt that our original unionid fauna can ever be restored. Perhaps our best hope is that the rate of decline can be slowed or reversed for some species at least.

We can quantify losses in a few groups such as mussels, because relatively thorough baseline inventories were conducted over a century ago. For most terrestrial invertebrates and plants, it has been almost impossible even to categorize species as secure or endangered because no such bases for comparison with earlier conditions are available.

Impact of the timber industry: Massive loss of broadleaf forest in Virginia seems to be increasing exponentially as extensive areas are being clear-cut and replanted in loblolly pine. One can scarcely drive 30 minutes on a backroad in our Piedmont and Coastal Plain without seeing truckloads of trees enroute to the sawmill, or pass cleared sites of an acre or square mile in extent. Many sites of potential interest are being transformed into pine plantations before even initial inventories could be made. I particularly regret this impact on the region of Pruetts and Spears mountains in

western Buckingham County, which I had the opportunity to traverse only once, noting the strong relief and pristine streams that invited investigation, before the arrival of logging machinery.

Burgeoning human populations: There are really two major escalating threats to the integrity of nature in Virginia today, both of them start with "de-". Deforestation has just been mentioned. Its partner is "development", the imposition of mankind's will upon nature. The population of Virginia has increased from about 3 million in my childhood to over 7.7 million in only about 70 years. While many parts of the state have seen population stability or even declines, there is no doubt that massive urbanization is taking place in the so-called crescent between Washington, D.C. and Norfolk. As recently as 1946, one drove between Fairfax and Arlington on a mostly two-lane US Highway 29 through a mosaic of fields, woods, and small settlements. The suburbs of Washington now extend 50 miles west and south. Anyone remembering the former Princess Anne County as a rural, thinly-populated countryside (with Sandbridge a desolate strand remote from nearest habitation), is appalled to be confronted by the doleful, sprawling complex of subdivisions, malls, and six-lane highways called Virginia Beach City. This litany could be extensively prolonged to include the leap-frog expansion of most of our cities. First Landing State Park, boxed in by beachside condominiums, is the Virginia version of New York's Central Park.

I think these two factors represent the most serious negative impacts on "Nature" in Virginia, and human increases naturally fuel further demands on forests for both paper and building materials. As long as our national economy is predicated on expansive consumerism, I see little hope that any form of population decrease or even stability will occur. Perhaps only depletion of fossil fuel supplies will result in condensation of our urban areas, as their cheap availability has created their expansion.

II. "NATURAL HISTORY"

What IS natural history? There are many concepts of what this term entails, and none seem really definitive. One is reminded of the Southern congressman who asserted "I can't give a definition of pornography, but I know it when I see it." Some common elements include the ecology and behavior of organisms under natural conditions. In my view, one must include also systematics and distribution of the organisms. In the usual context, "history" does not embody the sense of previous time, but a kind of formal documentation of information relative to the living components of the environment, it is of necessity a study, the accumulation of knowledge. In this sense, an astonishing amount of progress has occurred in Virginia during the past eighty years, in fact, most of it in the past forty. As a case in point: when I was just starting to develop an interest in "nature", the best tool for the aspiring ornithologist was Frank M. Chapman's field guide, which required actual birds in the hand for keying on the basis of beak, claw, and plumage characters. The "Peterson" category of field guides in color for many groups of animals and plants were still far in the future.

In terms of actual organized entities for promotion of natural history, several that come to mind are the Virginia Society of Ornithology, the Virginia Native Plant Society, the Virginia Archeological Society, the Virginia Butterfly Society, the Virginia Herpetological Society, and most recently, and philosophically the most comprehensive, our own Virginia Natural History Society (VNHS). Some local governmental initiatives are the Non-game Program of the Department of Game and Inland Fisheries, the Division of Natural Heritage of the Department of Conservation and Recreation, and the Virginia Museum of Natural History, all three just two decades in age, all charged with increase and diffusion of knowledge about our native biota and its environment. All state parks, and the majority of municipalities have developed self-guiding natural trails and provide instruction to visitors. Eighty years ago, there were no state parks: I was already 9 years old before Douthat (and five others) was operational!

Resources: Aside from the numerous pocket-sized field guides and larger more opulent manuals that describe many groups of rocks, fossils, plants, and animals on a regional basis, a number of surveys dedicated to Virginia's situation have appeared during the past several decades. We now have excellent books on our freshwater fish, reptiles, and mammals. There is a popular field guide to local geology as seen from the highway system, and another on the geology of Shenandoah National Park. The intricate stratigraphy of the Coastal Plain Tertiary formations has been deciphered and described in detail. Many areas are explained in regional geological field trip manuals. An atlas of the distribution of our flowering plants and conifers has gone through three revised editions, and is the precursor of a comprehensive *Flora of Virginia* now nearing completion. The "Insects of Virginia" series has produced 15 fascicles since 1969. VDGIF sponsored an elegant volume on the state's endangered plants and animals in 1991. The biogeography of the Southern Appalachians (with heavy emphasis on Virginia) has been addressed in the proceedings volumes of five

symposia convened between 1969 and 1999, another such volume was dedicated to the Great Dismal Swamp. The Virginia representatives of many groups of both animals and plants have been surveyed in the 33 issues of *Banisteria* published so far, and many others in the pages of other scientific journals. In short, the past three decades have seen a virtual explosion of access to many facets of Virginian natural history.

Some more downsides:

Less encouraging developments of the same period include the de-emphasis or abolition of organismal biology in our state universities, and drastically decreased support of state agencies like this museum.

III. NATURALISTS

Virginia may have been the Mother of Presidents, but she has never conceived anything like a corresponding number of naturalists. Although the Virginia colony can fairly be called the cradle of natural history in Virginia, after an impressive initial period the nursery has been only marginally occupied. Despite the anomaly of a remarkable landscape with a commensurate biotic diversity, after the demise of Jefferson and waning of his patronage, Virginians fell into self-absorbed gazing at the navel of human history, perhaps an outcome of the Jamestown-Williamsburg-Yorktown mystique. Only in geology, under the impetus of economic factors, was there much local interest in the natural world for many decades. Much of the fitful advances in knowledge is due to the interest of scientists from other places. While every county has had its own historical society, and heavily documented book, there was no natural history society until 1993.

What is meant by "naturalist"? The term can be defined in several contexts, with the gray area being the point at which someone who enjoys getting out into the woods for a hike, or simply likes watching birds at their backyard feeder, qualifies as a real naturalist. Unquestionably, thousands, if not millions, of people intuitively realize the spiritual benefits to be gained in that way and the number is obviously increasing. Another level embraces those who actively support environmental protection measures through donations, memberships, or positive votes in political referenda. Both of these categories grade into those who purchase field guides and actively learn to identify birds and wildflowers, often participate in natural history rallies or other instructional events. Collectively, people at these several levels of involvement may be considered "consumers" in that they rely on the expertise of those who know enough to generate basic information about natural processes and systems. They comprise the base levels of a pyramid, the pinnacle of which includes individuals committed to the actual systematic nuts and bolts work of collecting, documenting, synthesizing, and publishing. Maybe such persons can be called "producers", resulting in a complete reversal of the numbers distribution in an ecological trophic pyramid.

The historical record shows that within the past half-century, popular interest in natural history has increased dramatically, along with the availability of learning resources at every level of interest and sophistication. Educational television, public school instruction, many kinds of adult involvement opportunities, the complete spectrum from nature trail brochures, field guides, advanced manuals, attest to this fairly recent phenomenon. It has been accommodated by governmental agencies that address the issues of biodiversity, environmental quality, and the protection of both.

Remarkably, all of the foregoing opportunity has not been paralleled by a noticeable increase in the number of "producers" as just defined. One of the goals of the VNHS has been to facilitate, even generate, greater involvement in the sense of committed research into the "nature" of Virginia, but even with the ongoing excellence of local research as embodied in *Banisteria*, membership in the society has declined over the years. In particular, recruitment at the younger ages has been disappointing.

But can any amount of external (exogenous) stimulation, opportunity, and encouragement change these statistics? One must recognize the extent to which the "producers" are basically hobbyists who are pursuing their interests in more or less scientific patterns, call it research if you like, that generate new knowledge. As with other dedicated (even addicted) hobbyists, the motivation seems to be endogenous, some kind of compulsive intellectual mutation, which will express itself under unforeseeable, even unlikely, parameters.

But in Virginia, the opportunities for translating purely sensual enjoyment of Nature into an intellectual gratification are endless. In this respect serious study transcends the mere collector's urge that is a part of human nature. One can only hope that the quantum increase of interest in, and concern for, the natural world we have seen occur in Virginia during the past eighty years represents a momentum that sets the stage for a new level of active public involvement and support, and the VNHS should provide by its example the leadership into the new age.

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Leaf Beetles (Coleoptera: Bruchidae, Chrysomelidae, Orsodacnidae) from the George Washington Memorial Parkway, Fairfax County, Virginia

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ABSTRACT

One-hundred and seven species in 60 genera of bruchid, chrysomelid, and orsodacnid leaf beetles were documented from the George Washington Memorial Parkway in Fairfax County, Virginia. Three species (*Chaetocnema irregularis*, *Crepidodera bella*, and *Longitarsus alternatus*) are documented for the first time from the Commonwealth. The study increases the number of chrysomelid leaf beetles known from the Potomac River Gorge to 187 species. New host plant associations are noted for some species. Malaise traps and sweeping or beating vegetation with a hand net proved to be the most successful capture methods. Periods of adult activity based on dates of capture are given for each species.

Key words: Bruchidae, Chrysomelidae, Coleoptera, Fairfax County, leaf beetles, national park, new state records, Orsodacnidae, Virginia.

INTRODUCTION

The Chrysomelidae, or leaf beetles, are the second largest family of phytophagous beetles, with estimates ranging from 37,000 to 50,000 species worldwide, including approximately 1,700 species represented in North America (Lopatin, 1977; Jolivet, 1988; Riley et al., 2002). Larvae and adults feed primarily on leaves of aquatic and terrestrial host plants, but some species specialize on roots, stems, seeds, flowers, pollen, or detritus. Largely because of their feeding habits, but also through the transmission of plant viruses, members of this group include a number of agricultural and horticultural pests. Some intentionally introduced species have become effective biological control agents on invasive non-native plants. While most adults are small (1-10 mm) but boldly patterned and colored, the family also contains hundreds of cryptic species with unknown biological habits. Leaf beetles reach their highest species richness and abundance in open areas having a diverse flora (Greatorex-Davies et al., 1994; Masashi & Nagaike, 2006).

The Bruchidae, considered by some a subfamily of the Chrysomelidae, were given familial status by Kingsolver (1995) based on a number of morphological characters and their unique adaptations for ovipositing on seeds or fruits and pods containing seeds. They are also known for feigning death by falling from their perch with legs and antennae appressed to the body and head lowered. Approximately 1350 species are known worldwide, with 149 species documented from the United States (Kingsolver, 2002).

The Orsodacnidae consists of 30 species that were formerly placed in two subfamilies of the Chrysomelidae (Clark & Riley, 2002). Four species of orsodacnids are recorded from the United States (Riley et al., 2003).

Although the leaf beetles are one of the most

studied families of Coleoptera, and state level lists have been compiled by many authors (Balsbaugh & Hays, 1972; Downie & Arnett, 1996; Clark, 2000; Riley et al., 2003; Ciegler, 2007; Staines & Staines, 2009), no published systematic studies have been conducted in northern Virginia. This study sought to add to the knowledge of the leaf beetle fauna by compiling records, documented with a voucher specimen, from various studies conducted in the George Washington Memorial Parkway (GWMP), a national park in northern Virginia, and to determine whether any federally or state-listed rare, threatened or endangered leaf beetles occur within the study site. Currently, only one chrysomelid species (*Calligrapha pnirsa* Stål) is listed as rare in Virginia (Roble, 2013). This park includes areas along the Potomac River Gorge, an area noted for its biodiversity and regionally rare species (Evans, 2008).

STUDY SITE

The study site includes approximately 850 ha of lands managed by the National Park Service as units of the George Washington Memorial Parkway at Great Falls Park, Turkey Run Park, Dyke Marsh Wildlife Refuge, and Little Hunting Creek, Fairfax County, Virginia (Fig 1). Great Falls and Turkey Run parks fall within the Piedmont physiographic province while Dyke Marsh and Little Hunting Creek are on the Coastal Plain. All sites are situated along the shore of the Potomac River, and Great Falls and Turkey Run parks border the Potomac River Gorge. Most of the study sites are dominated by maturing, second growth, deciduous woodlands, but more open, herbaceous-dominated habitats can be found in narrow bands along the Potomac River and at Dyke Marsh. The vascular flora of the GWMP is diverse, with 1,313 taxa recorded, 1,020 from Great Falls Park alone (Steury et al., 2008; Steury, 2011).

Fig. 1. Location of study sites within the George Washington Memorial Parkway, a unit of the National Park Service, in Fairfax County, Virginia.

MATERIALS AND METHODS

The number of chrysomelid species documented from GWMP has grown since the first inventories targeting this family occurred in Turkey Run Park on two days in 1985 and 1986, when 14 species were recorded. This was followed by 14 days of chrysomelid survey effort conducted in 2005 and 2006 in Great Falls and Turkey Run parks, which documented 70 species. Survey methods for the 2005-2006 study consisted entirely of sweeping beetles from foliage with a net and hand picking specimens from plants. Both subsequent and prior to the 2005-2006 inventory, a number of additional studies have added leaf beetle specimens to the collections from GWMP, primarily as by-catch from studies targeting other arthropods. These include a Bioblitz held on 23-25 June 2006 which documented 19 species (Evans, 2008); a bee inventory at Great Falls Park in 2007 and 2008 utilizing yellow, blue, and white pan traps (Steury et al., 2009); surveys of sawflies, caddisflies, shoreflies, and beetles utilizing six Malaise traps set in Great Falls and Turkey Run parks from 2006 through 2008 (Steiner & Erwin, 2007; Smith, 2009; Flint, 2011; Flint & Kjer, 2011; Mathis & Zatwarnicki, 2012); studies of alderflies, ants, fireflies, and scorpionflies collected at pitfall or Malaise traps run at Dyke Marsh from 1998 through 2003 (Kjar & Barrows, 2004; Barrows et al., 2005, 2008; Barrows & Flint, 2009; Kjar, 2009) and studies targeting beetles captured by hand picking and in pitfall, Lindgren funnel, and blacklight traps set at Great Falls Park, Turkey Run Park, Dyke Marsh Wildlife Refuge, and along Little Hunting Creek in 2010 and 2011. Occasional collections by hand picking were made at other locations within GWMP in Arlington or Fairfax

counties. Specimens were pinned and deposited in the collections maintained at the George Washington Memorial Parkway, Turkey Run Park Headquarters in McLean, Virginia. Nomenclature follows Riley et al. (2003) and Kingsolver (2004). To determine new Virginia records, we reviewed Riley et al. (2003) and Staines & Staines (2009) and conducted searches in collections at the Virginia Museum of Natural History, Martinsville, Virginia (VMNH); National Museum of Natural History, Smithsonian Institution, Washington, DC (NMNH); and collections at Shenandoah National Park, Luray, Virginia and Bull Run Mountains Conservancy, The Plains, Virginia, and the private collection of Arthur V. Evans, Richmond, Virginia. New host plant associations were determined through a comparison of our records with those documented by Clark et al. (2004).

RESULTS

A total of 107 species in 60 genera and three families was documented from GWMP. No species in the family Megalopodidae (sometimes considered a subfamily of the Chrysomelidae) were documented from the study area. This represents 27.7% of the 386 chrysomelid taxa documented from Virginia (Staines & Staines, 2009). At least eight species reported from GWMP are not native to North America. Three native species (*Chaetocnema irregularis*, *Crepidodera bella*, and *Longitarsus alternatus*) were previously undocumented from the Commonwealth.

The 107 leaf beetle species collected from GWMP compares well with numbers listed for some of the most productive sites in adjacent Maryland. These sites include Soldier's Delight Natural Environment Area in Baltimore County (115 species), Green Ridge State Forest in Allegany County (82 species), Patuxent Research Refuge in Howard and Anne Arundel counties (57 species), and Sideling Hill Wildlife Management Area in Washington County (54 species) (Cavey & Staines, unpub. data). Staines (2004, 2008) reported 161 leaf beetle species from Plummers Island in the Potomac River Gorge of Montgomery County, Maryland, based on literature reviews, historical collections, and an inventory in 1997 and 1998, which added 15 species to the known fauna of the island. Collection effort at these five Maryland sites is at least equal to that at GWMP because all locations have been surveyed repeatedly for one or more decades. Thirty-five species documented from GWMP are not known to occur on Plummers Island, nine of which were found only at Dyke Marsh, 33.5 km southeast of Plummers Island and in a different physiographic province. However, 26 species not recorded from Plummers Island were found in Great Falls or Turkey Run parks located along the Potomac River Gorge within 6 km north and south of Plummers Island, respectively. These species bring the total number of chrysomelids documented from the Potomac River Gorge to 187 species. A total of 36 species was found at Dyke Marsh (16 unique to this site), 82 at Great Falls Park (36 unique), and 41 at Turkey Run Park (7 unique). No leaf beetles were captured at Little Hunting Creek where only Lindgren funnel and pitfall traps were used. One species from GWMP was added from Arlington County at Memorial Bridge. Sweeping or beating vegetation with a hand net proved to be the most successful method of capturing leaf beetles during this study, yielding 77 species. Malaise traps captured 63 species, pan traps and blacklight traps caught six species each, and pitfall traps collected three species, while Lindgren funnel traps failed to add any leaf beetles to the study.

Some of the most suitable leaf beetle habitat available at the study sites included two locations at Great Falls Park that were especially productive. Near coordinates N38° 59.680′ W77° 15.060′, the Central Appalachian Riverside Outcrop Prairie (sensu Steury et al., 2008) adjacent to the Potomac River harbors a diverse flora from which 15 leaf beetle species were taken. At the northern end of Great Falls Park (N39° 00.325′ W77° 15.336′), a hillside seep creates a small open wet meadow just west of an adjacent trail where 13 leaf beetle species were collected.

Most of the leaf beetle species known from GWMP have wide north-south ranges within their eastern United States distributions. However, two species collected in Great Falls Park are uncommon in the Mid-Atlantic area. Although recorded from a number of West Virginia counties by Clark (2000), *Capraita thyamoides* was known from only a few specimens at two locations in Maryland (Cavey & Staines, unpub. data) and was not listed for Virginia by Riley et al. (2003) or Staines & Staines (2009). *Crepidodera bella* was formerly known from coastal states between Texas and South Carolina until it was recently recorded from Maryland (Parry, 1986; Seago & Lingafelter, 2003) and North Carolina (Staines & Staines, 2009). Taken on its known *Salix* (willow) host during the survey, this collection of *C. bella* represents the first record from Virginia.

A species of *Calligrapha,* collected at Turkey Run Park by shaking branches of *Tilia americana* L. (basswood) in August 1985 and May 1986, is the most interesting leaf beetle taken from the park to date. These specimens closely resemble *Calligrapha scalaris* (LeConte), a species restricted to elm. Brown (1945) described several species similar to *C. scalaris* that have basswood as host, including *C. tiliae* Brown, *C.*

virginea Brown, and *C. amator* Brown, all recorded only from eastern Canada (Riley et al., 2003). The four biological species are quite difficult to separate, except perhaps in series and with a known host (Brown, 1945). Given this difficulty, this record from Virginia and similar observations recorded from West Virginia and Ohio (Clark, 2000), it is likely that members of this species complex (other than *C. scalaris*) occur in much of the United States but were either not reported or confused with *C. scalaris*. Repeated efforts to locate a population of this species during subsequent surveys at Turkey Run Park proved unsuccessful.

The genus *Longitarsus* has been in dire need of revision for at least 40 years. We used Horn (1889), Duckett (1920), and comparisons with identified specimens to identify the species reported here. The biology of the specimen reported as *Paria* n. sp. is important to its yet unpublished description. *Sumitrosis* sp. near *rosea* differs from *S. rosea* by its variable morphological characters and host plant preference. The *Psylliodes* sp. ♀ (*convexior* LeConte or *punctulatus* Melsheimer) and ♀ *Donacia subtilis* Kunze/*D. fulgens* LeConte complex can only be definitively distinguished based on male characters. All specimens collected of the latter two taxa were females.

LIST OF SPECIES

Nomenclature follows Riley et al. (2003) and families and species are listed alphabetically. Twenty-six species previously unrecorded from the Potomac River Gorge are marked with an asterisk (*). Eight species non-native to North America are signified with an exclamation point (!). Species are designated as rare (R) if 1-5 specimens were collected or observed, uncommon (U) for 6-12 specimens, and common (C) if more than 12 specimens were found. Sites where specimens were collected are given as Dyke Marsh Wildlife Preserve (DM), Great Falls Park (GF), or Turkey Run Park (TR). Others sites are spelled out as needed. The earliest and latest dates of collection are given for each species using three letter acronyms for the month. For trap sets over multiple weeks (rarely more than 14 days) the first day of the set is used as the earliest date and the last day of the set for the latest date. Collection methods are listed using the following abbreviations: black UV light (BL), sweep netting, beating sheets, and hand captures (HN), Malaise trap (MT), pan trap (PT), or pitfall trap (PF). Host plant associations are given when known.

BRUCHIDAE (Bean Weevils)

Acanthoscelides alboscutellatus (Horn) – U; DM; 19 Apr–28 Aug; MT

Althaeus hibisci (Olivier) – R; DM; 23 Jul–8 Aug; MT

Gibbobruchus mimus (Say) – R; GF; 16 Jul–3 Oct; BL, HN, MT. Collected on *Solidago bicolor* L.

Megacerus discoideus (Say) – R; DM; 14 Jun–9 Aug; MT

CHRYSOMELIDAE (Leaf Beetles)

Acallepitrix nitens (Horn) – R; GF, TR; 29 May–29 Jul.; HN

Acalymma vittatum (F.) – R; GF, TR; 5 Sep–21 Oct; HN, MT

Altica chalybea Illiger – C; DM, GF, TR; 10 Apr–21 Oct; HN, MT. Collected on *Vitis* sp., a known host.

Altica kalmiae Melsheimer – U; GF, TR; 14 Apr–20 Jul; HN, MT. Collected on *Kalmia latifolia* L.

**Altica litigata* Fall – R; GF, TR; 27 Apr–23 Aug; HN

Altica sp. *ignita* group – R; GF; 23 Jun; BL

**Anisostena nigrita* (Olivier) – R; GF; 6 Jun–16 Aug; HN. Collected on flowers of *Pycnanthemum tenuifolium* Schrad., an association not noted by Clark et al. (2004). Also swept from *Andropogon* sp., a reported adult association (Clark et al., 2004).

Baliosus nervosus (Panzer) – C; GF, TR; 10 May–16 Aug; HN, MT. Locally numerous, feeding on and mining (larvae) the leaves of *Tilia americana* L.

Bassareus mammifer (Newman) – R; TR; 24 June; HN

Brachypnoea clypealis (Horn) – C; GF, TR; 24 Jun–17 Aug; HN, MT

Brachypnoea tristis (Olivier) – R; GF; 15 Jul–29 Jul; HN

Calligrapha sp. near *scalaris* (LeConte) – R; TR; 28 Apr–12 May; HN, PF

Capraita obsidiana (F.) – R; DM, GF; 10 May–21 Oct; HN, MT

Capraita sexmaculata (Illiger) – R; DM, GF, TR; 10 May–29 Jul; HN, MT

**Capraita thyamoides* Crotch – U; GF; 9 Apr–23 Jul; HN, MT, PT

*!*Cassida rubiginosa* Müller – R; GF; 6 Jun; HN. Collected on *Carduus* sp., a known host.

Ceratoma trifurcata (Forster) – R; GF; 10–18 May; HN. Swept from an unidentified wild bean vine displaying typical adult feeding damage; this species feeds on numerous members of the Fabaceae (Clark et al., 2004).

Chaetocnema confinis Crotch – R; GF; 12–27 Apr; HN

Chaetocnema denticulata (Illiger) – R; GF, TR; 10 May–21 Oct; HN, MT. Handpicked from turf grass duff on 30 August.

Chaetocnema irregularis* LeConte – C; GF; 12 Apr–15 Jul; HN. Clark et al. (2004) associated this species with *Carex* and, to a lesser extent, *Scirpus* and *Juncus*. One or more of these plant genera occur at the northern portion of GF where this species was collected in numbers by sweeping. **NEW STATE RECORD

**Chaetocnema minuta* Melsheimer – R; GF; 9 Apr–12 Jul; PT

Chaetocnema pulicaria Melsheimer – U; DM; 12 Apr–5 Dec; MT

Chaetocnema quadricollis Schwarz – R; DM; 11 Apr; MT

**Chaetocnema truncata* White – R; GF; 23 Jun; BL

Chalepus bicolor (Olivier) – U; GF; 1 May–16 Aug; HN, MT

**Charidotella purpurata* (Boheman) – C; DM, GF; 19 Apr–18 July; HN, MT

Charidotella sexpunctata bicolor (F.) – C; DM, GF, TR; 28 May–8 Aug; HN, MT

Chrysochus auratus (F.) – R; GF; 8–9 Aug; HN. Netted on *Apocynum sibiricum* Jacq.

Colaspis brunnea (F.) – R; GF, TR; 12 Apr–20 Jul; HN, MT

Crepidodera bella* Parry – R; GF; 16 Aug; HN. This species has only been confirmed on *Salix nigra* Marshall (Clark et al., 2004), but the common willow at the site of this collection is *S. caroliniana* Michx., although *S. humilus* Marshall is also present. **NEW STATE RECORD

Crepidodera browni Parry – R; GF; 7 Jun–16 Aug; HN. Reported only on *S. nigra* and *S. fragilis* L. (Clark et al., 2004), but collected in an area where only *S. caroliniana* and *S. humilus* are present.

Crepidodera nana (Say) – R; DM; 11–25 Apr; MT

**Crepidodera violacea* Melsheimer – R; DM, GF; 19 Apr–21 Oct; MT

Cryptocephalus mutabilis Melsheimer – R; GF; 23 Jul; HN

**Cryptocephalus quadruplex* Newman – R; GF, TR; 18 May–7 Jun; HN

Deloyala guttata (Olivier) – C; DM, GF; 23 May–8 Aug; HN, MT

*!*Demotina modesta* Baly – U; GF; 16 Jun–21 Oct; HN, MT. In North America, this beetle has only been associated with *Quercus nigra* L. (Clark et al., 2004), an oak not among the 13 *Quercus* species found in Great Falls Park (Steury et al., 2008).

Diabrotica undecimpunctata howardi Barber – U; DM, GF; 14 Jun–11 Oct; BL, MT

Diabrotica virgifera Horn – R; DM; 23 Jul–4 Aug; MT

Dibolia borealis Chevrolat – R; GF, TR; 12 Apr–4 Aug; HN, MT

Disonycha admirabila Blatchley – R; Fairfax County, Collingwood Picnic Area; 16 Sep; HN. Collected in duff of turf grass.

Disonycha glabrata (F.) – R; GF, TR; 7 Jun–17 Aug; HN, MT. This species was collected in Turkey Run Park on *Amaranthus blitum* L., which can be added to the long list of other *Amaranthus* species listed by Clark et al. (2004) as hosts for this beetle.

Disonycha uniguttata (Say) – R; DM; 18 Jul–15 Aug; MT

Disonycha xanthomelas (Dalman) – R; TR; 7–21 Jul; MT

**Donacia biimpressa* Melsheimer – R; GF; 27 Apr–10 May; HN

**Donacia caerulea* Olivier – C; DM, GF; 11 Apr–21 Nov; HN, MT

Donacia fulgens LeConte – R; DM; 17–28 May; MT

Donacia piscatrix Lacordaire – U; DM; 10 May–12 Sep; HN, MT. Collected on *Nuphar lutea* (L.) Sm. ssp. *advena* (Ait.) Kartesz & Gandhi.

Donacia sp. ♀, *subtilis* Kunze / *fulgens* LeConte complex – R; DM; 12 Apr–18 July; MT

Epitrix brevis Schwarz – C; GF, TR; 10 May–7 Jun; HN. Collected in numbers on *Datura stramonium* (L.), a known host.

Epitrix fuscula Crotch – R; GF; 10 May–7 Jun; HN

**Exema canadensis* Pierce – R; GF; 9 Apr–16 Aug; HN, PT

Exema dispar (Lacordaire) – R; GF; 6 Jun; HN

Fidia longipes (Melsheimer) – C; DM, GF, TR; 19 Jun–1 Aug; HN, MT

Fidia viticida Walsh – C; DM, GF, TR; 24 Jun–8 Aug; MT

!*Galerucella nymphaeae* (L.) – C; DM; 7 July–15 Aug; MT. This species entirely skeletonized patches of *Nuphar lutea* (L.) Sm. ssp. *advena* (Ait.) Kartesz & Gandhi as large as 25 m x 25 m in Dyke Marsh in 2010.

*!*Graphops curtipennis* (Melsheimer) – R; GF, TR; 10–29 May; HN. Swept from *Hypericum* sp.

†*Hornaltica atriventris* (Melsheimer) – R; DM, GF; 12 Apr–21 Oct; MT

**Kuschelina fallax* (Melsheimer) – R; GF; 6 Jun–23 Jul; HN. Clark et al. (2004) listed *Agalinis fasciculata* (S. Ell.) Raf. and *A. strictifolia* (Benth.) Penn as known hosts for this species. Neither of these species are known from GWMP, however *A. purpurea* (L.) Pennellis is common at the site where this beetle was collected and is likely serving as its host plant.

Kuschelina gibbitarsa (Say) – U; GF, TR; 10 Apr–21 Jul; HN, MT

Kuschelina vians (Illiger) – R; GF; 27 Apr; HN

Labidomera clivicollis Kirby – R; Arlington County, Memorial Bridge; 8 Jun; HN. Collected on *Ilex opaca* Aiton (not feeding). Known hosts are in the Asclepiadaceae.

Lema trivittata Say – C; GF; 15 Jul–16 Aug; HN. Collected in numbers on *Datura stramonium* (L.), a known host.

Longitarsus alternatus* Ziegler – C; GF, TR; 10 Apr–17 Jul; HN, MT, PT. **NEW STATE RECORD

**Longitarsus* sp. near *arenaceus* Blatchley – R; GF; 12 Apr; HN

**Longitarsus testaceus* Melsheimer – R; GF; 10 May; HN

**Longitarsus turbatus* Horn – R; GF; 10 May; HN

**Microrhopala vittata* (F.) – R; GF, TR; 14–26 Jul; HN, MT

Neochlamisus bebbianae (Brown) – R; GF, TR; 14 Apr–6 Jun; HN

Neolema sexpunctata (Olivier) – R; GF; 31 Jun–17 Jul; MT. Collected sweeping *Commelina*, a known host.

Octotoma plicatula (F.) – R; GF; 7 Jun–15 Jul; HN. Adult collected on *Campsis radicans* (L.) Seem *ex* Bureau, the known larval host.

Odontota dorsalis (Thunberg) – U; GF, TR; 1 May–21 Jul; HN, MT

Odontota mundula (Sanderson) – C; GF, TR; 10 May–21 Jul; HN, MT. Collected sweeping *Amphicarpaea bracteata* (L.) Fernald, a known host.

Odontota scapularis (Olivier) – R; GF, TR; 10 May–24 Jun; HN

!*Oulema melanopus* (Linnaeus) – U; DM, GF; 19 Apr–7 Jul; HN, MT

**Oulema palustris* (Blatchley) – R; GF; 10 May–6 Jun; HN

Oulema sayi (Crotch) – R; TR; 23 Jul; HN

Pachybrachis femoratus (Olivier) – R; GF; 16 Aug; HN

Paria fragariae Wilcox – C; DM, GF, TR; 12 Apr–16 Aug; BL, HN, MT

Paria n. sp. – R; GF; 7 Jun; HN

**Paria quadriguttata* LeConte – R; TR; 1–20 May; MT

Paria quadrinotata (Say) – U; DM, GF, TR; 10 Apr–9 Aug; HN, PF, MT

Phyllobrotica limbata (F.) – R; GF; 3–17 Jun; HN, MT

Phyllotreta bipustulata (F.) – R; GF; 27 Apr–18 May; HN

Phyllotreta liebecki Schaeffer – R; DM, GF; 27 Apr–2 Jul; HN, MT

!Phyllotreta striolata (F.) – R; DM, TR; 18 Mar–10 May; MT

!Phyllotreta zimmermani (Crotch) – R; DM; 19–28 Apr; MT

**!Plagiodera versicolor* (Laicharting) – R; DM, GF; 8 May–7 Jun; HN, MT. Collected on *Salix*.

Plagiometriona clavata (F.) – U; DM, GF, TR; 19 Jun–8 Aug; MT

Plateumaris shoemakeri (Schaeffer) – U; DM; 12 Apr–20 Jun; MT

Plateumaris rufa (Say) – R; DM; 6–20 Jun; MT

**Prasocuris vittata* (Olivier) – R; GF; 12 Apr–10 May; HN. Clark et al. (2004) reported *Ranunculus acris* L. and possibly *R. repens* as hosts for this beetle, but neither of these two species occurs in Great Falls Park, thus *P. vittata* is likely using one of the other nine species of *Ranunculus* documented from the park by Steury et al. (2008).

Psylliodes sp. ♀ (*convexior* LeConte or *punctulatus* Melsheimer) – R; DM; 21 Nov–5 Dec; MT

Rhabdopterus picipes (Olivier) – U; DM, GF, TR; 19 Jun–23 July; HN, MT

Rhabdopterus praetextus (Say) – C; DM, GF, TR, 28 May–9 Aug; HN, MT

Saxinis omogera (Lacordaire) – R; GF; 22 May–7 Jun; HN, PT

Stenispa metallica (F.) – R; GF; 27 Apr–23 Sep; HN. Swept from *Scirpus* and *Carex* sedges in wet areas.

Sumitrosis inaequalis (Weber) – C; GF, TR; 9 Apr–4 Aug; HN, MT, PT. Collected mating on *Solidago* sp., a known host.

Sumitrosis rosea (Weber) – U; GF, TR; 10 May–21 Oct; HN, MT

Sumitrosis sp. near *rosea* – R; TR; 18 May–4 Aug; HN, MT. A species similar to *S. rosea* (Weber), collected on *Laportea* sp.

Systena elongata (F.) – R; DM, TR; 25 Apr–19 Aug; PT, MT

Tymnes tricolor (F.) – U; GF, TR; 15 May–21 Jul; BL, HN, MT

ORSODACNIDAE (Ravenous Leaf Beetles)

Orsodacne atra (Ahrens) – R; GF; 18 Mar–9 Apr; MT

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Ophiophagy in Red-shouldered Hawks (*Buteo lineatus*), with the First Record of Eastern Wormsnakes (*Carphophis amoenus*) as Prey

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ABSTRACT

The Red-shouldered Hawk (*Buteo lineatus*) is a diurnal raptor that preys primarily on mammals, amphibians, and reptiles. A literature review reveals that documented prey includes at least 26 species of snakes, 17 of which inhabit Virginia. Observations and circumstantial evidence are presented to document predation by Red-shouldered Hawks on Eastern Wormsnakes (*Carphophis amoenus*) and Rough Greensnakes (*Opheodrys aestivus*) in a suburban residential neighborhood near Richmond, Virginia. These are apparently the first records of the Eastern Wormsnake in the diet of Red-shouldered Hawks. Given the abundance of this small, fossorial, and secretive reptile in some habitats in Virginia, it may be an important type of prey for local predators such as the Red-shouldered Hawk.

Key words: Red-shouldered Hawk, Eastern Wormsnake, ophiophagy, predation, raptor.

INTRODUCTION

The Red-shouldered Hawk (*Buteo lineatus*) is a diurnal raptor that preys primarily on mammals, amphibians, and reptiles (Howell, 1911; Nicholson, 1930; McAtee, 1935; Ernst, 1945; Stewart, 1949; Portnoy & Dodge, 1979; Janik & Mosher, 1982; Welch, 1987; Crocoll & Parker, 1989; Howell & Chapman, 1998; Dykstra et al., 2003). Comparing these and other studies, including their own, Strobel & Boal (2010) concluded that there is geographic variation in the diet of this raptor, with northern populations tending to feed more on mammals and less on amphibians and reptiles as compared to southern populations (the same conclusion was reached by Dykstra et al., 2008). Strobel & Boal (2010) also found that Red-shouldered Hawks in some areas (e.g., Strobel's [2007] study site in Texas) eat considerable quantities of invertebrates, although they account for only a small portion of the estimated total biomass consumed.

Among reptilian prey, snakes are the main group consumed by Red-shouldered Hawks. My literature review revealed that at least 26 species of snakes, 17 of which inhabit Virginia, have been reported as prey of Red-shouldered Hawks (Table 1). Many older studies of raptor food habits typically did not identify the snake prey beyond the level of genus or even simply "snake" (see summary of numerous studies in Sherrod, 1978), and thus are omitted from this table. The Eastern Gartersnake (*Thamnophis s. sirtalis*) was documented as prey of Red-shouldered Hawks in 11 of 12 detailed studies cited in this table (the lone exception being Stewart, 1949).

Smyth (1894) and Johnston (2000) summarized numerous prey records for Virginia raptors. Four of five Red-shouldered Hawk stomachs examined by Smyth contained food items, collectively including a spider, three grasshoppers, a crayfish, and two "spring lizards" (salamanders). Johnston's sample of 26 Red-shouldered Hawk stomachs contained small mammals (shrews, mice, rats, squirrels, and chipmunks), salamanders, a painted turtle, snake scales, crayfish, spiders, and various insects (especially grasshoppers). Mitchell & Fischer (2008) stated that there were only three documented records of hawks preying on snakes in Virginia, but they overlooked Johnston's (2000) report of a Rough Greensnake (*Opheodrys aestivus*) in the stomach of an immature male Broad-winged Hawk collected in Fairfax County. Mitchell (1994) listed hawks (*Buteo* spp.) as known predators of this snake in Virginia. Tupacz (1985) reported a predation event involving a presumed Red-bellied Watersnake (*Nerodia e. erythrogaster*) and a Red-shouldered Hawk in the Dismal Swamp (City of Suffolk).

OBSERVATIONS

For at least half of the past 18 years, a pair of Red-shouldered Hawks has nested on or near my mostly wooded suburban property in northern Chesterfield County, Virginia, within 5 km of the City of Richmond limits. During 2005 and 2006, the nest was located 13-15 m above the ground in the crotch of a white oak (*Quercus alba*) tree in the front yard. On the afternoon of 30 April 2005, my youngest son and I were observing the nest, which contained two nestlings that I estimated were several weeks old. Our observations were made using 7 x 35 binoculars and a spotting scope (20x magnification) from a location about 15 m from the base of the nest tree. At approximately 1715 h, both adult hawks returned to the yard, with one landing at the nest and the other in a nearby tree. The adult hawk at the nest then proceeded to feed one of the chicks an Eastern Wormsnake (*Carphophis amoenus*), readily identifiable by its brownish dorsum and pink belly, which I estimated was about 30 cm long. The chick swallowed the snake whole, using several gulping motions to do so. This is apparently the first documented record of Red-Shouldered Hawk predation on Eastern Wormsnakes.

The hawks nested in the same tree the following year. At approximately 2000 h on 10 June 2006, I found a relatively fresh dead adult Eastern Wormsnake (total length 25.5 cm) lying upside down at the base of the nest tree. There were no signs that the snake had been eaten, but apparent bruises were evident. Three young hawks had fledged about a week earlier but they were still returning occasionally to the nest and adjacent perches. The ground where the snake carcass was found was dry and lacked leaf litter or other cover objects, which is atypical of the habitat utilized by Eastern Wormsnakes. I surmise that the snake had been captured elsewhere by an adult hawk and was subsequently dropped from the nest or a nearby perch by that bird or one of its offspring.

Table 1. Documented snake prey of the Red-shouldered Hawk (excludes records of snake prey that were not identified to species).

Species (common name)[1]	Source[2]
**Carphophis amoenus* (Eastern Wormsnake)	This report
**Coluber constrictor* (North American Racer)	4, 15, 16, 18
Coluber flagellum (Coachwhip)	4, 18
**Diadophis punctatus* (Ring-necked Snake)	2, 4, 8
**Heterodon platirhinos* (Eastern Hog-nosed Snake)	18
**Lampropeltis calligaster* (Yellow-bellied Kingsnake)	18
**Lampropeltis getula* (Common Kingsnake)	4, 16
Micrurus fulvius (Harlequin Coralsnake)	10
**Nerodia erythrogaster* (Plain-bellied Watersnake)	13, 18
Nerodia rhombifer (Diamond-backed Watersnake)	18
**Nerodia sipedon* (Northern Watersnake)	2, 12, 14
**Opheodrys aestivus* (Rough Greensnake)	2, 16, 18, this report
**Opheodrys vernalis* (Smooth Greensnake)	9, 14
**Pantherophis alleghaniensis* (Eastern Ratsnake)	16
Pantherophis emoryi (Great Plains Rat Snake)	18
Pantherophis obsoletus (Texas Ratsnake)	18
Salvadora grahamiae (Eastern Patch-nosed Snake)	18
**Storeria dekayi* (Dekay's Brownsnake)	15
**Storeria occipitomaculata* (Red-bellied Snake)	14
Thamnophis marcianus (Checkered Gartersnake)	18
Thamnophis proximus (Western Ribbonsnake)	18
Thamnophis radix (Plains Gartersnake)	15
**Thamnophis sauritus* (Eastern Ribbonsnake)	1, 2
**Thamnophis sirtalis* (Common Gartersnake)	2, 3, 4, 5, 7, 8, 9, 11, 12, 14, 16, 17, 18
**Virginia striatula* (Rough Earthsnake)	18
**Virginia valeriae* (Smooth Earthsnake)	5

[1]Some authors reported snake prey using scientific and/or common names that refer to their subspecific classification; the names included here are the common names for the full species following Crother (2008). * = species that occur in Virginia.

[2]Sources: (1) Merriam, 1877; (2) Fisher, 1893; (3) Hershey, 1923; (4) McAtee, 1935; (5) Trautman, 1944; (6) Stewart, 1949; (7) Craighead & Craighead, 1956 (8) Root & DeSimone *in* Sherrod, 1978; (9) Portnoy & Dodge, 1979; (10) Jackson & Franz, 1981; (11) Janik & Mosher, 1982; (12) Bednarz & Dinsmore, 1985; (13) Tupacz, 1985; (14) Welch, 1987; (15) Ernst & Barbour, 1989; (16) Howell & Chapman, 1998; (17) Dykstra et al., 2003; (18) Strobel, 2007.

This pair of hawks did not nest in our yard during 2007-2010, but the same (presumably) or another pair nested in a different white oak tree near the back corner of our house in 2011. During the nesting season, I occasionally checked the ground below the nest tree for evidence of dropped or partially eaten prey items. I did not find any wormsnake carcasses that year, but a dead juvenile Rough Greensnake (total length 23.7 cm) was found at the base of this tree by my sons on 2 June 2011 and four days later I found a dead adult female Green Frog (*Lithobates clamitans*; snout-vent length 68 mm) lying upside down in our driveway within 8 m of the tree. I believe both of these specimens had been captured and killed by the hawks. Since moving to this residence in the fall of 1993, I had never previously observed a Rough Greensnake in our yard and had rarely encountered Green Frogs away from a perennial, first order stream at the back of the property.

DISCUSSION

Craighead & Craighead (1956) previously reported that Red-shouldered Hawks prey on Green Frogs. Fisher (1893) and McAtee (1935) were apparently among the first authors to report finding greensnakes (*Opheodrys* sp.) in the stomachs of Red-shouldered Hawks, but they did not identify the prey to species (i.e., distinguish between Smooth and Rough Greensnakes). However, the lone specimen (of 220 total Red-shouldered Hawk stomachs) examined by Fisher that contained a greensnake was collected in Alabama, so the prey item must have been a Rough Greensnake because it is the only species of *Opheodrys* that occurs in that state (Gibbons & Dorcas, 2005). More recently, Howell & Chapman (1998) recorded an instance of predation by a Red-shouldered Hawk on a Rough Greensnake in Georgia, and Strobel (2007), using extensive data obtained exclusively by means of video surveillance cameras, reported that this snake was by far the most frequent reptilian prey (included 14 species of snakes; Table 1) of this raptor during his study in Texas, accounting for 164 total predation events (two-thirds of all predation events in which the snake prey was identified to species).

Most published studies of the food habits of Red-shouldered Hawks were conducted in states outside of or near the edge of the range of the Eastern Wormsnake. The studies by Stewart (1949) and Janik & Mosher (1982) were conducted in Maryland, which is within the range of this snake, but the only snake prey identified to species by these authors were the Eastern Gartersnake and Smooth Earthsnake (*Virginia valeriae*). Among the confirmed snake prey of Red-shouldered Hawks, those that are most comparable in size and habits to the Eastern Wormsnake, which is one of the smallest and most fossorial snakes in eastern North America (Mitchell, 1994; Orr, 2006), are species of *Storeria* and *Virginia*. The Eastern Wormsnake possesses a sharp point or spine on the tip of the tail that may be used as a defensive weapon against some predators (Linzey & Clifford, 1981; Gibbons & Dorcas, 2005). Wormsnakes are seldom active on the ground surface (Mitchell, 1994; SMR, pers. obs.) and do not bask (Clark, 1970). Palmer & Braswell (1995) reported that Eastern Wormsnakes are surface active mostly at night and Barbour et al. (1969) observed that most movements by Eastern Wormsnakes at their study site were initiated in late afternoon or early evening, with no movements initiated between midnight and 0300 h. Tennant & Bartlett (2000) believed that Eastern Wormsnakes are crepuscular and noted an instance where multiple individuals of this species were observed crawling erratically across a lawn during a rainy afternoon, attracting the attention of several songbirds (mostly American Robins, *Turdus migratorius*) in the process and resulting in one predation event by a Blue Jay (*Cyanocitta cristata*).

Studies by Barbour et al. (1969), Russell & Hanlin (1999), and Orr (2006) suggested that Eastern Wormsnakes are relatively sedentary, either moving short distances between successive captures or exhibiting site fidelity (i.e., captured under the same cover object multiple times). Despite its secretive habits, the Eastern Wormsnake can be a locally abundant species (Ernst et al., 1997; Willson & Dorcas, 2004), attaining densities exceeding 200 individuals per hectare in some parts of northern Virginia. It is by far the most common species of snake on my property, accounting for more than 90% of my observations over the past 19 years. The snakes have almost always been found under cover objects, such as leaf litter, rocks, logs, bark, boards, and flower pots, but occasionally were dug up during gardening activities.

Crocoll (1994; repeated by Dykstra et al., 2008) stated that the foraging behavior of Red-shouldered Hawks is not well studied. He cited published and unpublished sources indicating that the species hunts diurnally, usually from a perch in the forest canopy, although it also utilizes man-made structures such as poles, fences, and hay piles. Nicholson (1930) summarized its behavior thusly "The method of hunting food by this hawk is perching alertly on posts, dead trees, or stubs, out in the open, watching patiently by the hour for its prey, be it some luckless mouse, snake, or frog." Crocoll (1994) further noted that this raptor may search for prey by flying low over open habitats, snatch prey from the water surface, or hunt from the ground (where they

have been observed capturing small mammals emerging from their burrows; Coward, 1985). Stevenson & Anderson (1994) stated that Red-shouldered Hawks locate prey while in flight or from perches (fences, utility poles, and wires) and indicated that they usually fly directly to seize their prey. Johnsgard (1990) reported that aerial searching was probably the primary foraging method of this hawk, supplemented by searching from perches, whereas Dykstra et al. (2008) wrote "This hawk generally hunts from a perch, waiting for its prey to reveal itself and then swooping down to snatch it from the ground or water surface." Apparently, Red-shouldered Hawks in my neighborhood occasionally capture surface-active Eastern Wormsnakes that they detect from perch sites or while flying, or else they are searching in leaf litter and under easily-movable cover objects for this prey species. However, to my knowledge no one has ever observed Red-shouldered Hawks employing the latter type of hunting behavior, which seems unlikely. Several studies (e.g., Fisher, 1893; McAtee, 1935; Stewart, 1949; Craighead & Craighead, 1956) found one or more moles, another secretive type of vertebrate that is rarely observed above ground, in the stomachs of Red-shouldered Hawks. Perhaps the hawks locate moles and wormsnakes in a similar manner. Given the abundance of Eastern Wormsnakes in some habitats in Virginia, it may be an important type of prey for local predators such as the Red-shouldered Hawk.

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Status of Mabee's Salamander, *Ambystoma mabeei*, in Virginia: A Spatial Comparison of Habitat Condition at Sites of Known Occurrence

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ABSTRACT

Negative impacts of human settlements and population expansion on pool-breeding amphibians are well known. This, coupled with an increasing rate of urbanization across the globe, instigates the need for constant reassessment of habitat critical to the survival of these animals. In Virginia, the pool-breeding Mabee's Salamander (*Ambystoma mabeei*) is confined to the southeastern corner of the state. Knowledge about the populations and habitat quality within this range is limited. The goals of this project were to 1) visit known sites for *A. mabeei* in Virginia and reassess the habitat condition and species' occurrence and 2) assess changes in land use (1992-2001) in proximity to known sites for *A. mabeei* in Virginia and extrapolate the future of the species' occurrence at these sites. Visual Encounter Surveys were performed and land use data were analyzed within multiple buffer zones surrounding known sites. Over 80 ha of suitable habitat within 300 m of known sites for this species in Virginia were lost due primarily to human activity and land development.

Key words: *Ambystoma*, development, habitat, occurrence, range, spatial, urbanization.

INTRODUCTION

Globally, one of the major challenges faced by amphibians today is urbanization (Hamer & McDonnell, 2008; Tsuji et al., 2011). Amphibians tend to be especially sensitive to habitat effects such as habitat loss, fragmentation and isolation, and degradation, as well as alien diseases that result from urbanization (Alford & Richards, 1999; Houlahan et al., 2000; Mitchell, 2004; Gibbs et al., 2005; Cushman, 2006; Hamer & McDonnell, 2008; Baldwin & deMaynadier, 2009; Tsuji et al., 2011). Because more than 50% of the global human population resides in urban areas, and this population is growing constantly, this threat source is an ever-increasing cause for alarm in the conservation community (Tsuji et al., 2011). Other human stressors, such as intensive forest management that causes degradation to terrestrial amphibian microhabitat, as well as canopy removal, which alters ground level environmental conditions, can have large negative impacts on these amphibians (Freidenfelds et al., 2011).

In the United States, pool-breeding amphibians such as the mole salamander family, Ambystomatidae, and Wood Frogs (*Lithobates sylvaticus*) tend to be at high risk for multiple reasons (Hamer & McDonnell, 2008; Baldwin & deMaynadier, 2009; Freidenfelds et al., 2011; Tsuji et al., 2011). Compounding urbanization's negative impacts, pool-breeding amphibians in the U.S. also suffer from inadequate habitat protection in and around their breeding pools (Baldwin & deMaynadier, 2009; Freidenfelds et al., 2011). These breeding pools are often underrepresented in the U.S. Fish and Wildlife Service's National Wetland Inventory maps (Baldwin & deMaynadier, 2009). Silvicultural practices add another stressor for these amphibians (Freidenfelds et al., 2011). Outside of the breeding season, many pool-breeding amphibians emigrate from the pools into surrounding upland areas, making it critical habitat for conservation efforts (Mitchell, 2004; Baldwin & deMaynadier, 2009; Freidenfelds et al., 2011). Because the rate of urbanization is so high, frequent assessment of land use changes in areas bordering habitat known to support pool-breeding amphibians is imperative to the conservation of these species (Baldwin & deMaynadier, 2009).

One such animal belongs to the North American family Ambystomatidae. Mabee's Salamander

Fig. 1. Mabee's Salamander (*Ambystoma mabeei*) from the Grafton Ponds Natural Area Preserve, York Co., Virginia. Photo by S. M. Roble.

(*Ambystoma mabeei*; Fig. 1) inhabits Virginia along with five other ambystomatids, including *A. tigrinum* (Eastern Tiger Salamander), *A. jeffersonianum* (Jefferson's Salamander), *A. opacum* (Marbled Salamander), *A. talpoideum* (Mole Salamander), and *A. maculatum* (Spotted Salamander) (Mitchell & Reay, 1999). *Ambystoma mabeei* is a small ambystomatid, with adults reaching a total length of about 8 to 12 cm (Mitchell, 2005).

Adult *A. mabeei* inhabit forested areas, usually close to a suitable breeding site. Breeding sites consist of fish-free, ephemeral ponds in pine savannas, bogs, sinkholes, low wet woods, swamps, sandy pinewoods, or cypress-tupelo stands, as well as semi-permanent farm ponds, flooded foxholes, Carolina bays, and occasionally ponds in open, grassy fields (Hardy, 1969; Pague & Mitchell, 1991; Petranka, 1998; McCoy & Savitzky, 2004; Mitchell, 2005).

Both juveniles and adults of *A. mabeei* move considerable distances from the breeding pools after breeding and metamorphosis. Newly metamorphosed juveniles have been captured up to 800 m from their natal pond. Juveniles and adults remain fossorial outside of the breeding season. Information about underground activity in *A. mabeei* is lacking, but other *Ambystoma* species are reliant on underground tunnels. (Pague & Mitchell, 1991; Mitchell, 2004, 2005; Gamble et al., 2006)

According to the Virginia Fish and Wildlife Information System (VAFWIS), *A. mabeei* reaches the northernmost extent of its range in Mathews County, Virginia (Fig. 2). It also occurs in Gloucester, Isle of Wight, Southampton, Surry, and York counties and the cities of Hampton, Newport News, and Suffolk (Mitchell & Reay, 1999; Mitchell, 2005). The overall range of the species is restricted to the Coastal Plain regions of the Carolinas and Virginia (Pague & Mitchell, 1991; Petranka, 1998; McCoy & Savitzky, 2004).

The International Union for Conservation of Nature (IUCN) lists all Virginia species of *Ambystoma* except *A. mabeei* as having stable global populations. Although *A. mabeei* is noted as being in decline by IUCN, it is listed as a species of Least Concern (IUCN, 2009). Nature Serve ranks the salamander as G4, as it is "apparently secure" in its global range (Mitchell, 2005). The Virginia Department of Game and Inland Fisheries (VDGIF) lists *A. mabeei* as a State Threatened Tier II species of greatest conservation need in Virginia (Buhlmann et al., 2003).

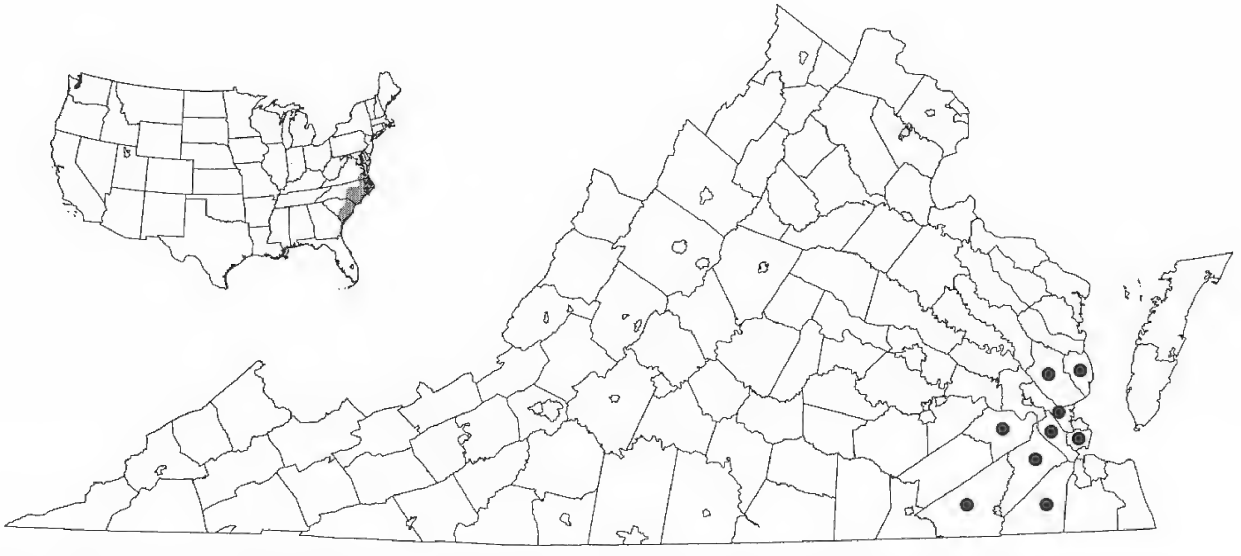

Fig. 2. Distribution of *Ambystoma mabeei* in Virginia and eastern United States (modified from Mitchell & Reay, 1999).

Due to increased human development in southeastern Virginia in recent decades, it is necessary to reassess the population status and habitat utilized by *A. mabeei* in the state. The goals of this project were to 1) visit known sites for *A. mabeei* and, when possible, reassess the habitat condition and species' presence at each and 2) assess changes in land use from 1992 to 2001 in proximity to known sites for *A. mabeei* in Virginia and 3) to extrapolate the future of the species' status at these sites.

METHODS

Initial assessments were made for all known localities of *A. mabeei* in Virginia using Google Earth satellite images. Visual Encounter Surveys (VES) were conducted at selected sites deemed not to have been destroyed upon the review of satellite images. Many sites were located on private property, and some sites were not visited due to lack of landowner permission during this early assessment period. Surveys were conducted from late January to February 2010 and in January 2011, between one and four times per site during the two-year period, when adults should be active (Mitchell, 2005). More extensive and repeated surveys, as well as surveys for larvae during the spring season, were not performed due to time constraints. Methods involved flipping logs near and surrounding ponds, gently combing through leaf litter, and limited searching in ponds for eggs.

In addition to field survey assessments, Arc Geographic Information Systems (ArcGIS) computer software program was used to assess changes in land use in proximity to known *A. mabeei* sites between 1992 and 2001. This period was chosen due to constraints of available National Land Coverage Dataset (NLCD) layers, which were obtained from the U.S. Department of Agriculture's Natural Resource Data website (MRLC, 2009). Known locations for *A. mabeei* were mapped from Global Positioning Systems (GPS) coordinates and separated into seven geographic units based on county location and geographic proximity to other sites. Buffers of 30 m, 50 m, 100 m, 200 m, and 300 m were established around known sites in order to examine changes in land use categories surrounding them.

A minimum buffer of 30 m was used because it is the required buffer size for mitigation and land protection surrounding wetland systems in Massachusetts, which is one of the strictest states for wetland protection (Gamble et al., 2006). In Virginia, no such mandatory upland protection exists. The maximum recommended buffer for Mabee's Salamander in Virginia is 250 to 300 m (VDGIF, 2010). The maximum buffer of 300 m is based on the Recovery Plan (Buhlmann et al., 2003). The three remaining interval buffers between 30 m and 300 m were chosen to allow for additional comparisons. Other studies of *Ambystoma* species have shown that animals emigrate between 30 and 1230 m from their breeding pools (Semlitsch, 1998; Facio, 2003; Gamble et al., 2006; Montieth & Patton, 2006). All buffers were created with dissolved boundaries in order to maintain an accurate representation of the area calculated for each unit, especially where proximal records caused overlapping buffer zones. Land use summary statistics were compiled and compared for all buffer regions in all subsets. Comparisons of land use categories were based on habitat types and our determination of habitat suitable for both terrestrial and breeding/larval aquatic stages for this species.

The definition of Suitable Habitat types derived from the NLCD files for the purpose of this paper is any forested or wetland areas. These consist of the following land use categories for both 1992 and 2001: Hardwood Forest, Pine Forest, Mixed Hardwood-Pine Forest, Forested Wetlands, and Emergent Wetlands. These land use types are considered to contain both suitable and marginal habitats. Marginal habitats are included in the Suitable Habitat category due to the possibility that these animals may experience limited dispersal abilities in some areas and be confined to using marginal habitat. The land use category of Open Water includes many waters which had a sustained fish presence at all times of year, and therefore was classified as unsuitable for use in the Suitable Habitat definitions. All land use types that did not fall into the category of Suitable Habitat (e.g., Open Space Developed, Barren Land, and Cultivated Crop) were treated as Unsuitable Habitat (Pague & Mitchell, 1991; Petranka, 1998; McCoy & Savitzky, 2004; Mitchell, 2005).

RESULTS AND DISCUSSION

Results from the assessments of land use within buffer zones surrounding known *A. mabeei* sites for each geographic unit are shown in Figures 3 through 9. The figures show Suitable Habitat change across the study period (1992-2001) for each of the five multiple ring buffers, with a total Suitable Habitat Change category also included. Suitable Habitat Change was calculated by subtracting the 2001 values of Suitable Habitat from the 1992 values, therefore a negative bar on a graph indicates a gain in Suitable Habitat.

Surry County

The area surrounding the one site record for the Surry Unit changed relatively little between 1992 and 2001 (Fig. 3). Major changes close to the GPS coordinates for the record show a shift from Forested Wetland to Hardwood Forest land use types, which could represent a loss of breeding habitat for these salamanders. Over the entire 300 m buffer zone, the site actually gained a total of 0.1 ha of Suitable Habitat from 1992 to 2001.

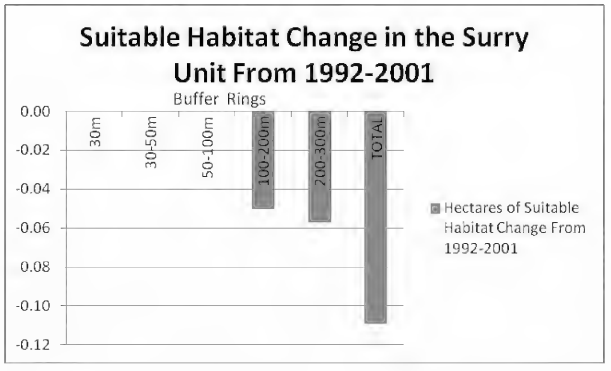

Fig. 3. A summary of statistics compiled for the single record of *Ambystoma mabeei* occurrence in the Surry Unit. Calculations were performed for each buffer zone, starting with the 0-30m zone and ending in the 200-300m zone. A net Total category was also established for an overall view. Change of Suitable habitat between 1992 and 2001 is shown here, amounting to a net gain of 0.11 ha of Suitable habitat.

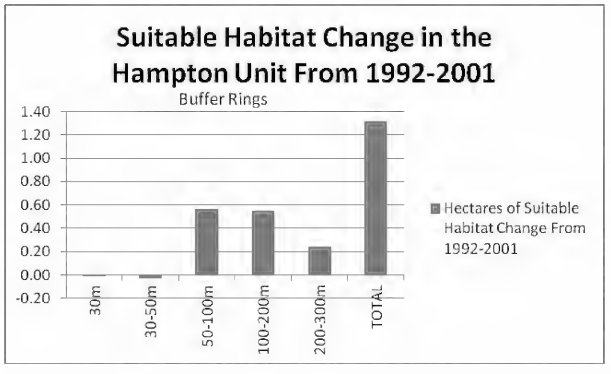

Fig. 4. A summary of statistics compiled for the two records of *Ambystoma mabeei* occurrence in the Hampton Unit. Calculations were performed for each buffer zone, starting with the 0-30m zone and ending in the 200-300m zone. A net Total category was also established for an overall view. Change of Suitable habitat between 1992 and 2001 is shown here, amounting to a net loss of 1.31 ha of Suitable habitat.

City of Hampton

While modest gains of Suitable Habitat were made within the 30 and 50 m buffer zones in the City of Hampton Unit, the total area lost more than 1.3 ha (Fig. 4). The greatest losses were made just beyond the 50 m buffer zone, with the 100 and 200 m buffer areas accounting for more than 1 ha of Suitable Habitat lost.

City of Suffolk

The three records in the City of Suffolk Unit display gains in Suitable Habitat in all buffer zones, totaling in excess of 7.7 ha (Fig. 5). This represents the highest proportion of Suitable Habitat gained among all subsets at more than a quarter of the total land area within the buffer zones being reclaimed.

Southampton County

No Suitable Habitat gains were made in the Southampton County Unit, which accounts for four records (Fig. 6). A total of 3.4 ha of Suitable Habitat was lost in this unit. Major habitat loss occurred within 200 meters of the records, accounting for 3.2 ha of the total Suitable Habitat lost.

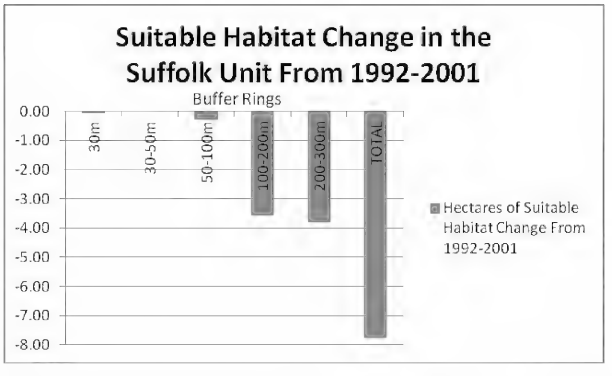

Fig. 5. A summary of statistics compiled for the three records of *Ambystoma mabeei* occurrence in the Suffolk Unit. Calculations were performed for each buffer zone, starting with the 0-30m zone and ending in the 200-300m zone. A net Total category was also established for an overall view. Change of Suitable habitat between 1992 and 2001 is shown here, amounting to a net gain of 7.75 ha of Suitable habitat.

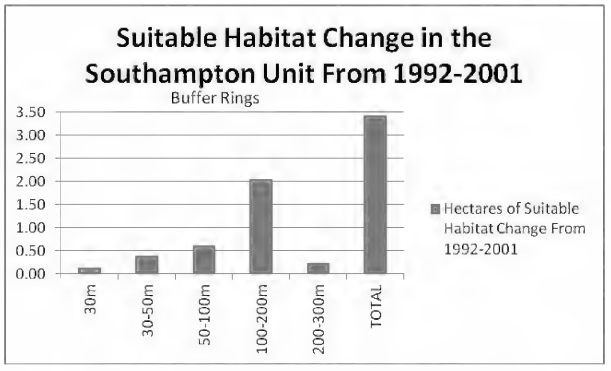

Fig. 6. A summary of statistics compiled for the four records of *Ambystoma mabeei* occurrence in the Southampton Unit. Calculations were performed for each buffer zone, starting with the 0-30m zone and ending in the 200-300m zone. A net Total category was also established for an overall view. Change of Suitable habitat between 1992 and 2001 is shown here, amounting to a net loss of 3.43 ha of Suitable habitat.

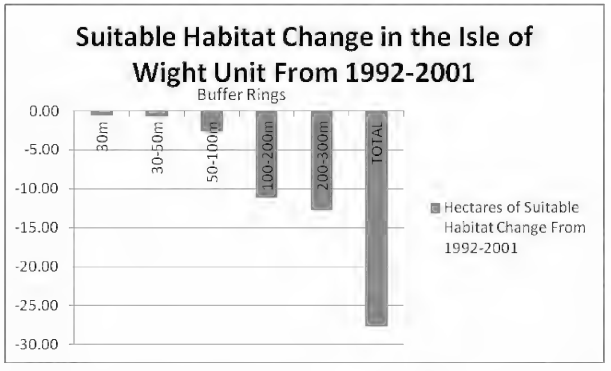

Fig. 7. A summary of statistics compiled for the seven records of *Ambystoma mabeei* occurrence in the Isle of Wight Unit. Calculations were performed for each buffer zone, starting with the 0-30m zone and ending in the 200-300m zone. A net Total category was also established for an overall view. Change of Suitable habitat between 1992 and 2001 is shown here, amounting to a net gain of 27.69 ha of Suitable habitat.

Isle of Wight County

The Isle of Wight County Unit, which contains seven records, displayed the highest total area of Suitable Habitat gained among all subsets (Fig. 7). More than 27.6 ha were gained in Suitable Habitat, representing a reclaiming of 23.2% of the total land area within the buffer areas surrounding these sites.

Gloucester and Mathews counties

The nine records located in the counties of Gloucester and Mathews Unit exhibit no gains in Suitable Habitat for any buffer areas. Gains of Pine

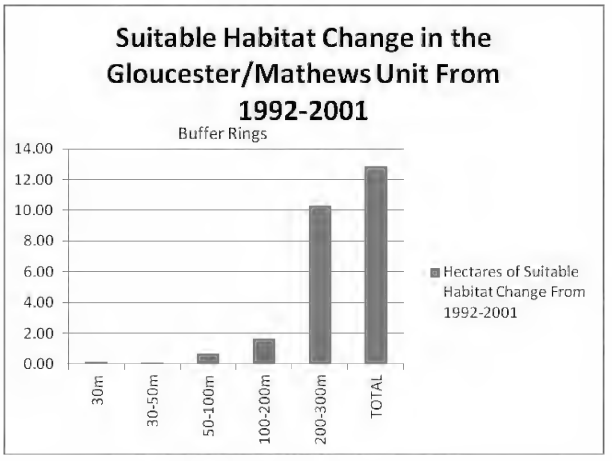

Fig. 8. A summary of statistics compiled for the nine records of *Ambystoma mabeei* occurrence in the Gloucester/Mathews Unit. Calculations were performed for each buffer zone, starting with the 0-30m zone and ending in the 200-300m zone. A net Total category was also established for an overall view. Change of Suitable habitat between 1992 and 2001 is shown here, amounting to a net loss of 12.88 ha of Suitable habitat.

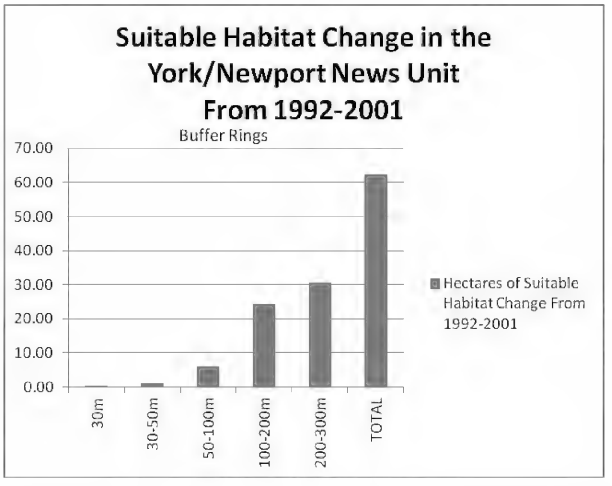

Fig. 9. A summary of statistics compiled for the sixty-four records of *Ambystoma mabeei* occurrence in the York/Newport News Unit. Calculations were performed for each buffer zone, starting with the 0-30m zone and ending in the 200-300m zone. A net Total category was also established for an overall view. Change of Suitable habitat between 1992 and 2001 is shown here, amounting to a net loss of 62.31ha of Suitable habitat.

Forest and Forested Wetland categories were offset by losses in Hardwood Forest, Mixed Hardwood-Pine Forest, and Emergent Wetlands categories. The total loss of Suitable Habitat in these two counties was 12.8 ha, with most losses between the 50 and 300 m buffer zones (Fig. 8).

York County and City of Newport News

The largest unit of records (n=64) exists in the York County and the City of Newport News Unit. Most of these occur in an area known as the Grafton Ponds Natural Area Preserve, and represent the largest known population of *A. mabeei* in Virginia. Of the 64 records, and more than 707.6 total ha, 62.3 ha were lost from Suitable Habitat categories between 1992 and 2001 (Fig. 9). Even though it represents less than 9% of the considered land area, this is still an enormous loss of potential habitat for this salamander in Virginia, especially considering that it was lost from an area that holds one of the most robust populations in the state. The land was lost in large part to increases in human development such as Low, Medium, and High Intensity Development, as well as to the Cultivated Crop and Barren Land (Rock/Clay/Sand) land use categories.

The information contained in Figures 3 through 9 is summarized in Table 1 on the basis of the Suitable Habitat parameters. In the overall study area, approximately 46.8 ha shifted from Suitable Habitat to Unsuitable Habitat between 1992 and 2001, but this figure is slightly misleading. In reality, more than 80 ha of Suitable Habitat were lost to multiple land use categories collectively in Virginia. This represents a significant loss for a species whose population may already be stressed in Virginia. On the other hand, approximately 35 ha of suitable habitat for *A. mabeei* were gained during the same time period. The Isle of Wight County Unit represents the highest percentage increase at more than 27 ha of suitable habitat reclaimed at seven sites. While this gain was not made as a result of any active habitat management program targeting *A. mabeei*, it nevertheless provides a potentially valuable source of habitat for this species.

Table 1. A summary of statistics compiled for the change in suitable habitat for *Ambystoma mabeei* across Virginia. Calculations were performed for each year over a total assessment of all buffer zones and all research Units. There has been considerable loss of suitable habitat surrounding known sites for *A. mabeei* during the 9-year period, amounting to a total of about 46 ha.

All of Virginia	1992	2001	Habitat Change, 1992 to 2001
Habitat quality	Hectares		
Suitable	971	925	-46
Unsuitable	261	307	+46
Total Hectares	1232	1232	

Due to the limited person-hours during this survey, no *A. mabeei* were encountered, thus no data regarding current presence/absence at the selected known sites was obtained. Survey sites were visited a maximum of four times across the two years. Additional VES may confirm presence of the species at some sites, but a lack of observations should not be viewed as proof that the species no longer occurs at these sites.

Human activity at some sites was confirmed during VES through both proximity to residences and presence of trash. Human activity around sites has also been confirmed by the comparison of development category land use values around the known sites from 1992 to 2001. Due to the secretive nature of *A. mabeei*, it is difficult to delineate population boundaries and where any migration corridors occur without the use of technologies such as radiotelemetry. Although we have documented a significant loss (46.8 ha overall) of potentially suitable habitat for this species, what remains to be studied is the effect that human activity has on fragmenting smaller populations, and how this translates into genetic isolation.

It is expected that some changes in forest type or other land use types will occur over time due to vegetative succession. Throughout the study area, Hardwood Forest held the highest acreage value of all land use categories within buffer zones for both years, but is considerably lower in total acreage in 2001 compared to 1992. Pine Forest experienced a sharp increase from 1992 to 2001, presumably due to silvicultural practices. Given the scope of this project, per-site analyses were not performed. This is important to note because known populations of *A. mabeei* in Virginia are sparsely distributed, and the destruction of key breeding sites may result in loss of populations. This may in turn negatively impact their ability to disperse, again causing a possible decline in genetic variability among individual populations.

Suggestions for further research on *Ambystoma mabeei* populations in southeastern Virginia include revisiting this study on a per-site analysis basis. Following the completion of our analyses, the U.S. Department of Agriculture finalized delineation of a new NLCD representing the year 2006, as well as an NLCD 1992/2001 Retrofit Land Cover Change product. Analysis of these two Land Cover Data sets would provide a more accurate and current land use assessment and provide another data point to evaluate ongoing land use trends. Further VES would assist in providing confirmation of the presence or absence of remaining populations at known sites, which would allow for a more accurate overall assessment of the future presence of *A. mabeei* in Virginia.

As is true in much of the United States, no mandatory protection of upland habitat areas surrounding ephemeral wetlands exists in Virginia, a fact that needs to be addressed because a significant portion of the life cycle of *A. mabeei* and other pond-breeding amphibians depends upon extensive use of wooded upland systems (Semlitsch, 1998; Facio, 2003; Jenkins et al., 2006). Capture-recapture and radiotelemetry studies would also assist in assessing density and home range of *A. mabeei* populations in Virginia, and may prove crucial to future legislation pertaining to wetland/upland protection. Biologically delineated salamander life zones, which represent critical wildlife habitat, should be considered a viable means to estimate the area of upland protection that should be applied, and should be utilized in forest management practices (Semlitsch, 1998; Facio, 2003; Montieth & Patton, 2006).

On a broader scale, loss of ephemeral wetlands is a major concern for numerous species, and for local, state, and federal organizations in the U.S. (Van Meter et al., 2008). Geographic Information Systems should be incorporated into new studies, including multiple land cover data sets to develop a model for predicting and delineating ephemeral wetlands across the landscape. The effects of human proximity and anthropogenic activities to these wetland systems are little known, but could have a high impact because these ponds are often fed by groundwater and runoff (Carrino-Kyker & Swanson, 2007). This relationship should be examined in more detail to determine the effect it is having on salamander populations within breeding pools. Habitat fragmentation is also a significant threat to pond-breeding amphibians and needs to be addressed in future studies utilizing GIS (Semlitsch, 1998; Rothermel & Semlitsch, 2002; Skidds et al., 2007).

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Shorter Contributions

Banisteria, Number 41, pages 93-94

A PROBABLE NEARSHORE RECORD OF KILLER WHALE (*ORCINUS ORCA*) ON ASSATEAGUE ISLAND, VIRGINIA. — Killer Whales (*Orcinus orca*) are found worldwide in oceans but are uncommon in the western North Atlantic south of Nova Scotia (Katona et al., 1988; Mitchell & Reeves, 1988; Reeves & Mitchell, 1988a, b; Hairr, 2012). There are no stranding records in Virginia (Blaylock, 1985; Potter, 1991) and only two sight records in Virginia waters: (1) at the edge of the continental shelf (36° 46′ N, 74° 38′ W) approximately 118 km east of Virginia Beach (Katona et al., 1988); and (2) about 35 km east of Rudee Inlet, Virginia Beach (Koonce, 2002). Here I report a probable nearshore sighting of Killer Whales from Assateague Island, Accomack County, Virginia.

On the morning of 25 November 2007, I saw a pod of cetaceans (as many as seven individuals) from the beach on Assateague Island (37° 53.05′ N; 75° 20.66′ W). Distance was difficult to judge, but I estimated the pod was 400-600 m offshore. Observation with binoculars revealed that the dorsal fins were significantly taller than those of Atlantic Bottlenose Dolphins (*Tursiops truncatus*), the most frequently observed cetacean in the coastal waters of Virginia (Blaylock, 1985). I attempted several digital photographs with a Canon PowerShot A570 camera through a spotting scope set at 20X (Swarovski HD-ATS 65), but only one photograph captured the breaching whales (Fig. 1). The image showed two cetaceans, a submerged individual with a triangular dorsal fin (upper panel of Fig. 1) and a second breaching individual with curved dorsal fin (upper and lower panel of Fig. 1).

Fig. 1. Killer Whales (*Orcinus orca*) photographed from the shore of Assateague Island, Virginia, on 25 November 2007.

I sent the photographs to James G. Mead and Charles W. Potter, cetacean specialists at the National Museum of Natural History, Smithsonian Institution. Both concluded that the cetaceans were most likely Killer Whales, representing a male (triangular fin) and female (curved fin). I then sent the photograph to an *Orca* specialist, Robert L. Pitman (Southwest Fisheries Research Center, NOAA Fisheries Service, La Jolla, CA), who replied (pers. comm.), "I think the dorsal fin of the lead animal looks awfully heavy for a *Grampus* [= *G. griseus*, Risso's Dolphin], and the fin of the back animal is suspiciously triangular. Also, the animals are quite black and the lead animal has what appears to be a rounded melon - I think if it was *Grampus* you could see the flatter front or even the cleft in the anterior portion of the melon. And I also agree, there could be an eye patch in there, either obscured by a bow wave or under water. I think they could be killer whales." On the basis of the photographic evidence, the Killer Whale should be placed on the provisional list of marine mammals recorded in coastal Virginia waters.

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CHARACTERISTICS OF A BLACK RAIL (*LATERALLUS JAMAICENSIS*) TERRITORY IN HUNTLEY MEADOWS, FAIRFAX COUNTY, VIRGINIA.—The Black Rail (*Laterallus jamaicensis*) is a rare breeding species in brackish and salt marshes in the Chesapeake Bay watershed (Robbins & Blom, 1997; Rottenborn & Brinkley, 2007). Occasional inland reports (May-July) suggest sporadic breeding in freshwater marshes although nesting has yet to be documented. The most celebrated Virginia record in recent memory occurred during the summer of 2002, when Kurt Gaskill discovered a singing male on 10 June in the non-tidal freshwater wetlands of Huntley Meadows County Park (HMCP), Fairfax County (Iliff, 2002; Rottenborn & Brinkley, 2007). Observation notebooks archived at HMCP indicate that the rail was reported on at least 21 days from 11 June through 13 July 2002. Although this was the first record of Black Rail in Fairfax County and among only a handful of inland records for Virginia during the past 50 years (Rottenborn & Brinkley, 2007), no documentation was submitted because the Avian Records Committee of the Virginia Society of Ornithology did not require documentation for this species at the time from Coastal Plain localities. The purpose of this note is to present a brief description of the habitat frequented by the rail and notes on its behavior.

I mapped the rail's territory on seven days, 22 June to 4 July, by tracking its vocalizations from the elevated boardwalk that winds across the floodplain of Barnyard Run with a global positioning system (GPS) receiver. The rail frequented a roughly circular area of marsh (ca. 0.47 ha) centered inside the boardwalk loop (38°45.24′ N, 77°6.28′ W). The areas of greatest singing frequency were dominated by thick monocultures of lizard's-tail (*Saururus cernuus*) and scattered patches of cattail (*Typha latifolia*) growing on mud or in shallow water (<5 cm) pooled behind a meandering series of low beaver dams (Fig. 1). Approximately 10% of the territory was covered by pools of open water or exposed mud. The water level in the territory was relatively stable, varying by no more than a few centimeters, during the observation period.

Fig. 1. Stands of lizard's-tail (foreground) and cattail frequented by a Black Rail in Huntley Meadows County Park, Fairfax County, Virginia, from 10 June to 13 July 2002.

I recorded the rail's vocalizations with a Marantz PMD430 cassette recorder and a Sennheiser ME 80 directional microphone (Fig. 2). The rail delivered the "*keekee-doo*" song and shorter "*kee-doo*" variants intermittently from dawn (0515 h) until dusk (1945 h). Both song variants are believed to be given by males (Eddleman et al., 1994). Singing bouts typically lasted

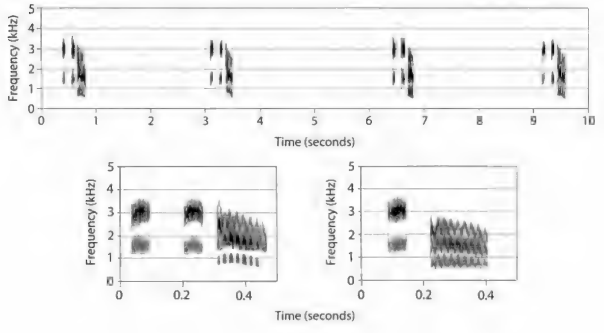

Fig. 2. Audio spectrograms of Black Rail songs recorded at Huntley Meadows County Park, Fairfax County, Virginia, on 3 July 2002. Upper panel shows the temporal spacing of "*keekee-doo*"songs during a typical singing bout. Spectrographic detail of the first song in the series is shown in the lower left panel. An example of the "*kee-doo*" song variant is shown in the lower right panel.

several minutes (as long as 13 minutes) followed by silent periods of variable length (few minutes to several hours). The song rate counted during three 1-minute periods was 16, 17, and 19 songs per minute. The rail appeared to be little affected by the presence of observers on the boardwalk. On several occasions it walked under the boardwalk during singing bouts. The presumed male was probably unmated because there was no evidence of additional birds. It apparently departed the area in mid-July, as repeated attempts to relocate the bird in late July and August were unsuccessful.

I thank Phyllis and Mort Isler for making spectrographs from my sound recordings and the staff at HMCP for providing access to the observation logs.

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Banisteria, Number 41, pages 95-97

HUMMINGBIRDS VISIT FEEDERS AT HIGH-RISE APARTMENT BUILDINGS. — Many species of birds have shown a remarkable ability to adapt to anthropogenic habitats (Graves, 2004) and adjust their foraging behavior to take advantage of novel food sources (Fisher & Hinde, 1949; Martin & Fitzgerald, 2005). No taxonomic group demonstrates this better than hummingbirds (Trochiliformes), which rapidly learn to visit sugar-water feeders. However, the extent to which hummingbirds exploit artificial food resources in high-density urban environments is largely undocumented. A review of peer-reviewed literature revealed no reports of hummingbirds visiting feeders at high-rise apartment buildings.

Here I report Ruby-throated Hummingbirds (*Archilochus colubris*) visiting sugar-water feeders at a high-rise apartment building in College Park, Prince George County, Maryland. It was brought to my attention that hummingbirds had visited feeders and potted plants on the upper balconies from May through September, 2011. The apartment resident contacted me again in June 2012 to report that hummingbirds were visiting the same balcony feeders. I visited the apartment complex on 26 July 2012 and observed two hummingbirds visiting feeders on balconies on the 14th and 15th floors (Fig. 1). The highest feeder was 43 m above ground level (measured with a Bushnell laser range finder). Both individuals were observed trap-lining among feeders, potted plants, and hanging baskets scattered among the balconies of the upper floors of the apartment complex. A few direct flights from the balconies to the adjacent forest and vice versa were observed but hummingbirds mostly perched on balcony trellises between foraging bouts. In one case, a departing individual was observed flying over the building (~50 m above ground level). A walk around the two high-rise buildings, both of which were comprised of 16 floors, revealed hummingbird feeders on six different balconies (two each on the 15th and 14th floors and one each on the 13th and 12th floors). Feeders were of similar design with red "nectar" receptacles. The nearest natural habitat, a relatively large tract of deciduous forest (>200 ha), was ~60-70 m from the apartment buildings.

These observations raise an interesting question: How do hummingbirds discover high-rise feeders? Red plastic feeders probably act as visual beacons. The spectral sensitivity of hummingbird photoreceptors ranges from the near ultraviolet (~350 nm) through red wavelengths (~700 nm) of the visual spectrum (Goldsmith & Goldsmith, 1979; Goldsmith, 1980; Herrera, et al., 2008). However, most ornithophilous plants in North America have red or orange flowers (Grant, 1966; Grant & Grant, 1968). Two climbing lianas in the middle Atlantic states, trumpet vine (*Campsis radicans*) and cross vine (*Bignonia capreolata*), have large reddish-orange flowers, or red and yellow flowers (5-7 cm) that are primarily pollinated by the Ruby-throated Hummingbird

Fig. 1. Arrows mark the location of hummingbird feeders on the balconies of a high-rise apartment building in College Park, Maryland. The highest feeder was 43 m above ground level.

(James, 1948; Bertin, 1982). The ornithophilous biology of the trumpet vine was noted as early as the 18th century (Catesby, 1731: 65 and facing plate) and John James Audubon painted a veritable swarm of hummingbirds at a cluster of trumpet vine blossoms (Audubon, 1835a, b). Both lianas regularly ascend trees to a height of 15 m (Graves, pers. obs.). Hummingbirds are undoubtedly accustomed to encountering nectar sources well above ground level. In any case, the vertical distance between the highest naturally-occurring flowers and high-rise apartment feeders is inconsequential for a species with such extraordinary powers of flight.

Is there a limit to how high Ruby-throated Hummingbirds will fly to reach high-rise apartment feeders? The answer probably depends on the density of feeders, hanging baskets, and potted plants on lower floors and the distance of the building from natural habitat. However, under ideal conditions, I would not be surprised to learn that Ruby-throated Hummingbirds visit high-rise apartment feeders 50-75 m above ground. This constitutes yet another example of innovative foraging behavior in a group of birds already renowned for behavioral flexibility.

I thank Leslie Reinhardt for alerting me to the presence of hummingbird feeders at high-rise apartments and Leslie Overstreet (Joseph F. Cullman 3rd Library of Natural History, Smithsonian Institution Libraries) for bibliographic advice.

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VACUSUS VICINUS (LAFERTÉ-SÉNECTÈRE) (COLEOPTERA: ANTHICIDAE): NORTHERN RANGE EXTENSIONS TO VIRGINIA, MARYLAND, MISSOURI, AND KANSAS. — Published records typically cite the general range for *Vacusus vicinus* (LaFerté-Sénectère) (Coleoptera: Anthicidae) as the southern United States to Venezuela and the Caribbean, including Cuba, Hispaniola, Jamaica, Lesser Antilles, Puerto Rico, and the Virgin Islands (Werner, 1983). It has also been reported from Hawaii (Werner, 1966). Thus, a northern range extension was suspected when individuals of this ant-like flower beetle were recently collected from two sites in a National Park, George Washington Memorial Parkway (GWMP), in northern Virginia (Fairfax County). Searches of twelve entomological collections (AMNH, ANSP, CUAC, DMNH, GWMP, MCZ, NMNH, VMNH, UCRC, UDCC, UMRM, and UNHC) confirmed reports of *V. vicinus* from Mexico and Central America and North American specimens were located from Alabama, Arizona, Arkansas, southern California (Imperial, Los Angeles, and Riverside counties), Florida, Georgia, Kansas, Louisiana, Maryland, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Texas, and Virginia. The northern limit of this species is defined based on the following specimens: **MARYLAND, Talbot Co.**: Wittman, at Harris Creek, 38°47′42″N, 76°16′35″ W, 18 August 1974, W. E. Steiner (NMNH). **VIRGINIA, Fairfax Co.**: Dyke Marsh, 38°46′ 28.21″ N, 77°3′0.32″ W, sandy tidal beach, 15 May 2012, B. Steury (GWMP); Collingwood Picnic Area, turf grass at edge of parking lot, 9 June 2012, B. Steury (GWMP). **MISSOURI, Boone Co.**: Columbia, 38°92′ N, 92°34′ W, 5 March 1946, W. S. Craig (UMRM). **KANSAS, Crawford Co.**: Pittsburg, 37°24′ N, 94°42′ W, 27 June 1954, E. L. Todd (NMNH). The records from Maryland, Missouri, and Kansas are of single specimens and it is unknown if they represent ephemeral introductions or are part of native populations.

Other Virginia specimens of *V. vicinus* at NMNH and VMNH are from Halifax, Northampton, Nottoway, Mecklenberg, and Isle of Wight counties, and the City of Virginia Beach. The recent collections from Fairfax County extend the northern range limit within the Commonwealth by 250 km from a site in Nottoway County.

Label data indicate that specimens have been collected at artificial lights, sometimes in large numbers; series have also been found under leaf litter on sand or sandy soil and in beach drift debris at or above the high tide line.

Werner (1961) stated that *V. vicinus* is variable in color with specimens from the southern part of the range having luteous to rufous elytra with a dark apex and interrupted submedian band, while specimens from the northern portion of the range possess largely piceous elytra. Both color variations are represented in the collection from Fairfax County: the Dyke Marsh specimen possesses rufous elytra with a dark apex and interrupted submedian band and the Collingwood Picnic Area specimen has piceous elytra tinted rufous at the base. The only other Anthicidae in the collections from the George Washington Memorial Parkway, all from Fairfax County, Virginia, are: *Acanthinus myrmecops* (Casey), *Anthicus cervinus* (LaFerté-Sénectère), *Macratia murina* (Fabricius), *Malporus cinctus* (Say), *Notoxus murinipennis* (LeConte), *Sapintus fulvipes* (LaFerté-Sénectère), *Sapintus pubescens* (LaFerté-Sénectère), *Stricticollis tobias* (Marseul), and one *Tomoderus* sp. female.

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Peter Adler (CUAC), Charles Bartlett (UDCC), Lee H. Herman (AMNH), Phil Perkins (MCZ), Jason Weintraub (ANSP), Robert W. Sites (UMRM), Jean L. Woods (DMNH), and Doug Yanega (UCRC) reviewed their collections for specimens of *Vacusus vicinus.* The late Richard Hoffman provided all Virginia anthicid records at VMNH just prior to his passing. We gratefully acknowledge their assistance.

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Banisteria, Number 41, pages 98-99

THE COLUMBINE SAWFLY, *PRISTIPHORA RUFIPES* SERVILLE, NEW TO VIRGINIA, AND OTHER ADDITIONS TO THE LIST OF VIRGINIA SAWFLIES (HYMENOPTERA: TENTHREDINIDAE)

— A sawfly damaging cultivated columbines, *Aquilegia* spp. (Ranunculaceae),

Fig. 1. Female of *Pristiphora rufipes*.

was first discovered in Ottawa, Ontario, in 1963 and was identified as the European *Pristiphora aquilegiae* (Vollenhoven) (MacNay 1963, 1964). Although called *P. aquilegiae* in the literature and on websites (e.g., Hahn, 2006), the current, correct name for the species is *Pristiphora rufipes* Serville (Taeger et al., 2010). In 1985, this columbine sawfly was first reported from the United States in New York and has since spread into adjacent states south to Pennsylvania, West Virginia, and west to Minnesota and Illinois (personal notes, unpublished reports). Three collection records in 2012 are the first records for Virginia and, to date, represent the southernmost records for the species: Fairfax Co., Holmes Run ~¼ mi NE jct. Gallows Rd. & I-495, 38°50′ N, 77°12′ W, MT, V.6-12.2012, D. R. Smith (1♀); Prince William Co., Bull Run Mountain Conservancy, Beverly Mill by Broad Run, 38°49.465′ N, 77°42.630′ W, IV.21-V.7.2012, Mal. trap, D. R. Smith (1♀); Prince William Co., Bull Run Mts., Jackson Hollow campground area, 38°52.682′ N, 77°41.348′ W, VIII.3-23.2012, Malaise trap, D. R. Smith (1 ♂).

The adult (Fig. 1) is a typical-looking sawfly, about 6 mm long and black with the labrum, palpi, and tegulae whitish and most of the legs pale orange. Larvae are green with a slightly darker head. Young larvae begin feeding on the leaf edges and eat inward, devouring all of the leaf tissue except the midvein (Hahn, 2006). Defoliation can be severe, leaving only bare stems and flowers intact. There may be two generations a year, adults and damage of the first generation appearing in April or May.

Following my recent revision of *Periclista* subg. *Neocharactus* (Smith 2012), the *Periclista* section of my Virginia sawfly list (Smith, 2006) needs revising. Four species are new to Virginia (indicated by an asterisk), and the *Periclista* species are now placed in subgenera. For those in *Neocharactus*, the entries should be completely replaced; for those in *Periclista*,

only additions are noted.

**Periclista* (*Neocharactus*) *absens* Smith.
Arlington, Essex, Fairfax, Loudoun. Host: *Quercus*.

**Periclista* (*Neocharactus*) *asper* Smith.
Essex. Host: *Quercus*.

Periclista (*Neocharactus*) *inaequidens* (Norton).
Essex, Fairfax, Prince William. Host: *Quercus*.

**Periclista* (*Neocharactus*) *major* Smith.
Hanover, Rockingham. Host: *Quercus*.

Periclista (*Neocharactus*) *subtruncata* Dyar.
Fairfax, Fauquier, Prince William. Host: *Quercus*.

**Periclista* (*Neocharactus*) *varia* Smith.
Essex, Fairfax. Host: *Quercus*.

Periclista (*Periclista*) *albicollis* (Norton).

Periclista (*Periclista*) *bipartita* (Cresson)

Periclista (*Periclista*) *diluta* (Cresson).
Add: Prince William

Periclista (*Periclista*) *marginicollis* (Norton)
Add: Prince William

Periclista (*Periclista*) *media* (Norton).
Add: Prince William

There were 345 Symphyta species listed in 2006. With the addition of *Kerita fidala* Ross (Smith, 2009) and the above five, the total is now 351.

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RE-IDENTIFICATION OF *ALASMIDONTA TRIANGULATA* FROM VIRGINIA. - The late Richard Hoffman recently published a paper on the identification of specimens collected in 1988 as *Alasmidonta triangulata* (Lea, 1858) from Halifax and Mecklenburg counties, Virginia (Hoffman, 2012). Both collection sites are located in the Roanoke River basin. Johnson (1970) recognized *A. triangulata* as a valid species occurring in the Ogeechee, Savannah, and Wateree River drainages of the South Atlantic slope. Hoffman (2012) reported that Clarke (1981) had examined the clinal increase in shell inflation of *Alasmidonta undulata* (Say, 1817) from Maine to South Carolina and considered *A. triangulata* to be a local variant and junior synonym of *A. undulata*.

The taxa discussed here are: *Alasmidonta undulata*, type locality is the Delaware and Schuylkill rivers [near Philadelphia, Philadelphia Co., Pennsylvania] (Johnson,

1970: 349; Clarke, 1981: 38); *Alasmidonta arcula* (Lea, 1838), type locality is the Altamaha [River], Liberty [now Long] County, Georgia (Johnson, 1970: 352; Clarke, 1981: 48); *Alasmidonta triangulata* (Lea, 1858), type locality is the Upper Chattahoochee [River], Georgia (Johnson, 1970: 351; Clarke, 1981: 38; Williams et al., 2008).

Bogan et al. (2008) reviewed the phylogenetic relationships of all extant species referred to the genus *Alasmidonta*. This genus is restricted to the eastern United States and currently contains 12 species (Clarke, 1981; Turgeon et al., 1998; Williams et al., 2008). *Alasmidonta* is divided into two subgenera, *A.* (*Alasmidonta*) is restricted to the rivers of the Atlantic Slope and *A.* (*Decurambis*) to the Mississippi River basin and the Gulf Coast (Bogan et al., 2008; Williams et al., 2008).

Analyses performed by Bogan et al. (2008) support recognizing as valid species: *A. arcula*, *A. undulata* extending from Maine to South Carolina, and *A. triangulata* restricted to the Chattahoochee River basin (Brim Box & Williams, 2000; Williams et al., 2008, 2011). Populations reported as *A. triangulata* by Hoffman (2012) from the Ogeechee River, Georgia, were identified by Bogan et al. (2008) as *A. arcula*.

The results of the genetic analyses do not support the identification of the Virginia specimens as *A. triangulata* or the occurrence of that species in Atlantic Slope rivers. This work, combined with the observations of Clarke (1981) on the clinal variation of the shell inflation and thickness, supports the identification of the Virginia specimens as *A. undulata*. Five Virginia Museum of Natural History lots of *A. triangulata* collected by Hoffman from Halifax and Mecklenburg counties were examined and re-identified as *A. undulata*. The identification of *A. triangulata* in southern Virginia, based on shell shape (Hoffman, 2012), is a misidentification.

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Viewpoint

Banisteria, Number 41, pages 101-107

Rectifying the Inequity and Bias: The Case for Investigating Non-Insect Terrestrial Invertebrates in the Southeastern United States

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ABSTRACT

Except for insects, terrestrial organisms are rarely addressed in invertebrate-oriented zoology courses. The focus understandably is marine, but ignoring the diverse, air-breathing invertebrates deprives students of learning opportunities that can potentially lead to jobs in environmental consulting and management, for example at the 901 areas with preserved terrestrial habitat in the southeastern United States. Environmental management agencies depend on zoologists for basic faunal information and cannot preserve what they do not know. University classes can conveniently investigate terrestrial invertebrates in conjunction with trips to marine labs, both in forests along highways leading to the coast and in ones near the labs themselves. Introducing undergraduate students to terrestrial invertebrates is necessary to eliminate the information void on these organisms.

Key words: environmental management, habitat, marine, milliped, organisms, Southeast, zoology.

INTRODUCTION

On 9 March 2013, the North Carolina State Museum of Natural Sciences (NCSM) hosted a symposium on non-insect terrestrial invertebrates in the southeastern United States (US), defined as the region east of the Mississippi and south of the Ohio and Potomac rivers (Fig. 1). It constituted the initial effort to rectify the unjustified bias against these organisms in this region, and to our knowledge it was also the first meeting on this topic ever held in North America. Presentations covered planarians, nematodes, earthworms, leeches, gastropods, isopods, diplopods, chilopods, spiders, opilionids, scorpions, acarines, and miscellaneous arachnids. The event was cited in *Banisteria* and widely publicized to university biological science departments, governmental agencies, and environmental consulting firms, although few outsiders attended. Nevertheless, the participants learned a lot about organisms that regional zoologists have been stepping on, trampling, and squashing all their lives without even noticing. I present below my introductory talk that briefly describes my zoological background and how I discovered this general field and realized how biased my training had been. These magnificent, highly evolved, and specialized organisms are generally ignored in invertebrate-oriented zoology courses in favor of marine organisms, and it is time for this inequity to end.

NARRATIVE

I cannot remember a time when I did not know that I wanted to be a zoologist. Even at age 4, when my parents enrolled me in Mrs. Sykes' Rhythm School after World War II, I knew that illuminating and enhancing knowledge of animals was my life's mission.

At the University of North Carolina-Chapel Hill (UNC) in the early 1960s, I took every zoology course I could fit in my schedule and experienced a

Fig. 1. Southeastern United States, as defined at the NCSM Non-Insect Terrestrial Invertebrate Symposium, 9 March 2013.

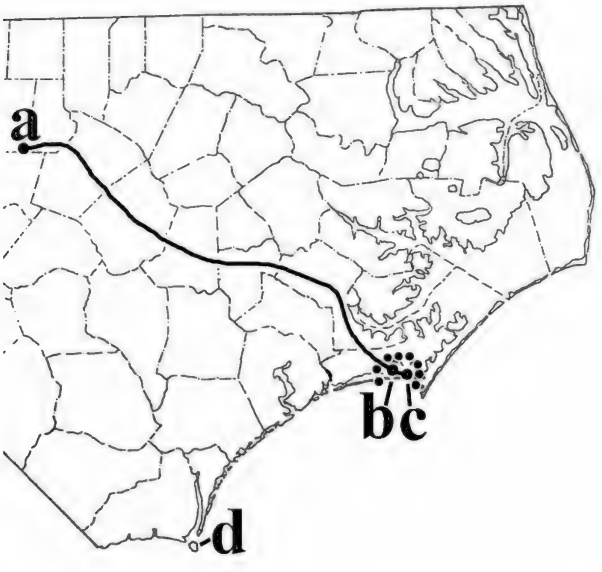

Fig. 2. Approximate course of US highway 70 from UNC-Chapel Hill (a) to the UNC Institute of Marine Sciences, Morehead City (b), and the Duke Marine lab, Beaufort (c). The area of coastal forests that can be conveniently investigated while visiting these marine labs is denoted by the arc of small dots. Bald Head Island (d) is the easternmost site for the xystodesmid milliped, *Apheloria tigana*.

breakthrough in the one on Invertebrate Zoology. The professor led the class on several field trips to the UNC and Duke marine labs, in Morehead City and Beaufort, respectively (Fig. 2), and I was shocked by the staggering diversity of marine organisms. I had no idea that life of this magnitude existed and became hooked on invertebrates, an exciting, though phylogenetically artificial, assemblage. I concluded that invertebrates are where the action is in zoology and where I was heading professionally.

In the pre-interstate highway era, driving from Chapel Hill to Morehead City/Beaufort on US 70 took three hours, and with one exception, we drove straight to the coast. On that occasion, the professor stopped at a bridge so students could dip their nets into a stream and view aquatic life, but we never stopped at a field or forest in any successional stage to view terrestrial organisms. We learned in lectures about US marine and oceanographic laboratories – particularly those at Dauphin Island, Alabama; the University of Miami; Sapelo Island, Georgia; the Baruch Lab, South Carolina; Virginia Institute of Marine Science; Woods Hole, Massachusetts; Friday Harbor, Washington; and Scripps, California – but equivalent terrestrial biological labs and field stations (Fig. 3) – such as Mountain Lake, Virginia; Highlands, North Carolina; Tall Timbers and Archbold, Florida; the Southwestern Research Station, Arizona; and the Hastings Natural History Reservation and other University of California Natural Preserves – were never mentioned. I recall "covering" both myriapods and arachnids in two lectures. Devoting substantially more time to marine organisms is understandable because life began in the sea and its biodiversity far exceeds those in freshwater and on land, but doing so to the veritable exclusion of the multitudinous non-insect, air-breathing invertebrates is not. This constitutes an overt and tacit bias that deprives students of learning opportunities and sends the erroneous message that such organisms are somehow "inferior" and/or zoologically insignificant. Undergraduate students are likely to accept without question the inherent messages in such biases, and I was not the only one in this course who did.

When I became the first Invertebrate Curator at the NCSM in 1971, I received one instruction from the Director: "Don't work with marine organisms, because there are numerous coastal marine labs, or insects, because there are too many and entomology programs exist at three regional universities – NC State, Virginia Tech, and Clemson. Work with aquatic and terrestrial invertebrates that nobody is studying." As all I knew then were the marine invertebrates that he said to avoid, I was momentarily lost, but I had always been fascinated by multilegged arthropods. I toured the

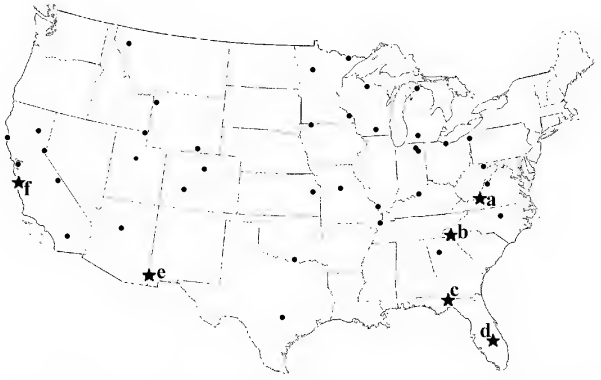

Fig. 3. US terrestrial biological field laboratories in 1966. Those mentioned in the text are (a) Mountain Lake, Virginia; (b) Highlands, North Carolina; (c, d) Tall Timbers and Archbold, Florida; (e) Southwestern Research Station, Arizona; (f) Hastings Natural History Reservation, California.

Smithsonian Institution's invertebrate holdings and Ralph Crabill, Curator of Myriapods and Arachnids, allowed me to view the milliped (diplopod) collection under the watchful eye of his technician. At that time I didn't know one diplopod from another, but I was astounded by the diversity of colors, sizes, and body forms and shocked to realize that what I thought was a minor and insignificant zoological class is actually enormously diverse. This led me to wonder, "I took the invertebrate course at a major university, why weren't students told this? Why didn't classes stop at least once to look for millipeds on all those coastal field trips?" I had found my group and, with mentoring from Richard Hoffman (Fig. 4), began sampling them in the Southeast, where I was again stunned by the diversity and numbers of non-insect invertebrates in every conceivable biotope. Never having learned otherwise, I thought only a handful of land snails existed and all spiders build webs. I also observed obviously different earthworms and isopods, pseudoscorpions on many decaying logs, and obviously different opilionids gliding over the substrate.

How could my invertebrate professor have induced the monstrously false impression that land invertebrates barely warrant mention and only marine invertebrates warrant study? I learned the answer in 1974 at a statewide conservation meeting that he also attended. During a 15 minute break, I wandered through a wooded area smaller than a football field and collected around 4-5 milliped orders and 9-10 families, which I put in a jar to show him. He eyeballed them quickly, handed the jar back, and said, "OK." How many zoological classes are there in which one can find that level of diversity in that short a time in that small an area without even trying? Not very many. I had just shown a zoology professor something he did not know, and he shrugged it off. He was so into his marine bias that he had little interest in air-breathing organisms, and while everyone is entitled to biases, he unintentionally transferred his to impressionable students.

University curriculums and courses have changed dramatically since the 1960s, but to my knowledge most invertebrate-oriented classes still conduct field trips to marine labs without spending even 15 minutes examining air-breathing organisms in terrestrial habitats along the highways they travel. What is the reason for this glaring omission? Can it be as simple as the fact that they do not live in water? In order to survive outside of water, these invertebrates had to solve formidable biological problems, for example desiccation. Organisms cannot reproduce and sustain species if they dry out, shrivel up, and die, and

Fig. 4. Richard Lawrence Hoffman (1927-2012), Grand Master of Diplopodology.

some land invertebrates actually thrive in arid deserts. Excretion is another problem for terrestrial organisms, which have to detoxify and eliminate nitrogenous waste without depleting their body fluids and again, drying, shriveling, and dying. Respiration is yet another. A gill is useless outside of water; air-breathing organisms had to evolve new respiratory structures and even systems, and they did all of these and more quite successfully. On a global scale, many land invertebrate taxa are enormously diverse, having radiated into vast arrays of environments and biotopes. Consequently, I submit that the fact that these invertebrates live outside of water makes them more interesting, not less; this is all the more reason to study them and all the more reason to introduce students to them.

Today's environmental age provides a practical reason to investigate air-breathing organisms and teach students about them; doing so can lead to employment opportunities and jobs. Environmental consulting is a relatively new profession in which faunal surveys are conducted and Environmental Impact Statements and governmental regulations are addressed. National and state parks/forests employ salaried "resource specialists," but effective management requires detailed knowledge of the organisms inhabiting the environments, and the responsibility for generating this knowledge lies with zoologists. Invertebrates are fundamental components of terrestrial ecosystems, but since most zoologists ignore them, it is difficult, if not impossible, for environmental managers to obtain needed information. In the Southeast, 901 areas with natural habitat (172 and 729 at federal and state levels, respectively), many with environmental managers and resource specialists, have been preserved, and this figure omits historic sites, battlefields, university and private forests (Appendices 1-2), and National Monuments, as with the possible exception of Russell Cave, Alabama, all southeastern National Monuments are primarily historical with little if any natural area. Though preserved primarily because of their "wet" features, National Seashores and Wild and Scenic Rivers contain terrestrial ecosystems, inhabited by air-breathing organisms, that require management just as do the marine and aquatic environments. Even minute patches of quasi-natural habitat can harbor significant terrestrial invertebrates, as exemplified by Buxton Woods and Nags Head Woods preserves, which share the North Carolina Outer Banks with Cape Hatteras National Seashore and municipalities like Nags Head, Kitty Hawk, and Kill Devil Hills (Fig. 5). Five indigenous diplopods inhabit the former and two, the latter (Shelley, 2000) (Table 1); they range westward to the central Plains, north to New England/Canada, and south to Florida/Gulf States. In the Xystodesmidae (order Polydesmida), *Apheloria tigana* Chamberlin occurs on Bald Head Island, south of Wilmington and Ft. Fisher (Figs. 2d, 6), despite vacation homes and golf courses (Shelley & McAllister, 2007), and *Sigmoria latior hoffmani* Shelley inhabits woods adjoining the strand at Edisto Beach, South Carolina (Fig. 7) (Shelley & Whitehead, 1986). Farther south, *Sigmoria australis*

Fig. 5. Outer Banks of North Carolina showing the locations of Cape Hatteras National Seashore (dotted lines), Nags Head Woods (triangle), and Buxton Woods (large dot).

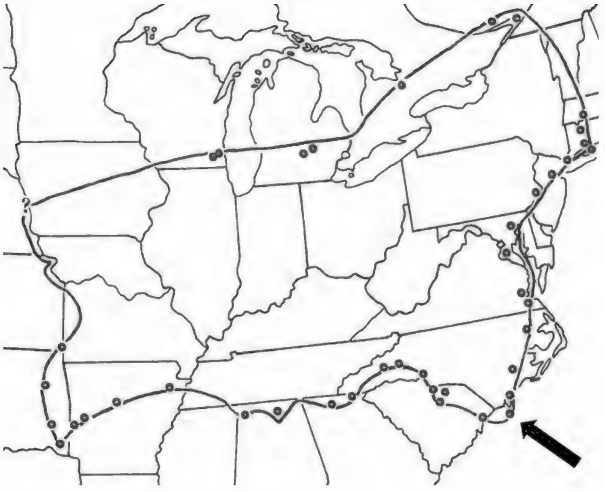

Fig. 6. Distribution of *Apheloria* showing the occurrence of *A. tigana* on Bald Head Island, North Carolina (arrow).

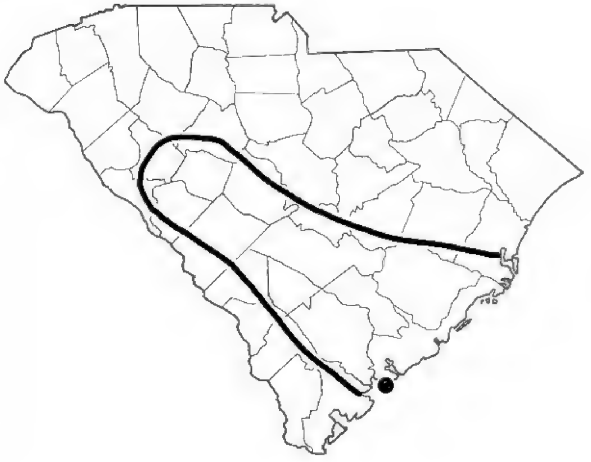

Fig. 7. Distribution of *Sigmoria latior hoffmani* showing occurrence on Edisto Beach, South Carolina (dot).

Shelley and *S. serrata* (Shelley) inhabit coastal forests of South Carolina, Georgia, and Florida, and the entire known range of the latter is the forested islands and narrow strip of land east of interstate highway 95 (Fig. 8) (Shelley, 1984; Shelley & Whitehead, 1986). Consequently, if professors choose not to investigate terrestrial environments along the highways to marine labs, they and their students can do so on the coast itself (Fig. 2), when cars are parked and marine activities are not feasible. Coastal woodlands harbor significant, native, air-breathing organisms, and anthropochores wander walkways and hide in mulch at marine labs as well as on inland campuses. Though not of systematic value, the latter demonstrate the diagnostic features of their taxa and can be readily examined under marine-lab microscopes. Terrestrial invertebrates lack swimming appendages and the feathery, frilly gills of marine organisms, but they are no less evolved and

Table 1. Distributions of indigenous millipeds on the North Carolina Outer Banks.

Species (Order: Family)	Nags Head Woods	Buxton Woods	Western range limits	Northern range limits	Southern range limits	References
Virgoiulus minutus (Brandt) (Julida: Blaniulidae)	X		se OK & e TX	s MI & NY	n peninsular FL & Gulf Coast w to LA	McAllister et al., 2005
Pseudopolydesmus serratus (Say) (Polydesmida: Polydesmidae)	X	X	Fargo, ND, central KS, eastcentral TX	Fargo, ND to Québec City, Québec	FL panhandle & Gulf Coast to s TX	Shelley & Snyder, 2012
Scytonotus granulatus (Say) (Polydesmida: Polydesmidae)		X	e NE to e OK	sw Québec to Sault Ste. Marie, Ontario	s AR, n MS, & AL, s coastal SC	Shelley, 1994; Shelley et al., 2005
Oriulus venustus (Wood) (Julida: Parajulidae)		X	Edmonton, Alberta to se Utah	Edmonton, Alberta to n NY & VT	Gulf Coast of LA	Shelley, 2002
Narceus americanus (Beauvois) (Spirobolida: Spirobolidae)		X	westcentral OK & central TX	Upper Peninsula of MI to s Québec	Big Pine Key, FL & Gulf Coast of TX	Keeton, 1960; Shelley et al., 2006
Cleidogona sp. (unidentifiable ♀) (Chordeumatida: Cleidogonidae)		X	NA	NA	NA	

Fig. 8. Distributions of *Sigmoria australis* (triangles) and *S. serrata* (dots); the open box outlines occurrences along the coastal strips of South Carolina, Georgia, and Florida.

specialized for their microhabitats. If zoologists are to fulfill their role in today's environmental age, they and their students need to learn about the multitude of air-breathing invertebrates that have survived for hundreds of millions of years in the detritus beneath their very feet. It is time to end the overt bias against terrestrial organisms and for students to be routinely introduced to them in invertebrate-oriented zoology courses.

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Appendix 1. Federally preserved natural areas in the Southeast.

National Parks (8): Biscayne, Congaree, Dry Tortugas, Everglades, Great Smoky Mountains, Mammoth Cave, Prince William Forest, Shenandoah.

National Parkways (5): Blue Ridge, Colonial, Foothills, George Washington, Natchez Trace.

National Seashores (6): Assateague, Canaveral, Cape Hatteras, Cape Lookout, Cumberland Island, Gulf Islands.

National Recreation Areas (3): Chattahoochee River, Gauley River, Land between the Lakes.

National Preserves (2): Big Cypress, Timucuan Ecological and Historic.

National Wild and Scenic Rivers (4): Big South Fork, Bluestone, New, Obed.

National Historical and Scenic Trails (4): Appalachian, Natchez, Overmountain Victory, Trail of Tears.

National Forests (26):

Alabama (4): Bankhead, Conecuh, Talladega, Tuskegee.
Florida (3): Appalachicola, Ocala, Osceola.
Georgia (2): Chattahoochee, Oconee.
Kentucky (1): Daniel Boone.
Mississippi (6): Bienville, Delta, Desoto, Holly Springs, Homochitto, Tombigbee.
North Carolina (4): Croatan, Nantahala, Pisgah, Uwharrie.
South Carolina (2): Francis Marion, Sumter.
Tennessee (1): Cherokee.
Virginia (2): George Washington, Jefferson.
West Virginia (1): Monongahela.

National Wildlife Refuges (116):

Alabama (10), Florida (29), Georgia (11), Kentucky (1), Louisiana (6 east of the Mississippi River), Mississippi (17), North Carolina (10), South Carolina (8), Tennessee (8), Virginia (14), West Virginia (2).

Appendix 2. State-level preserved natural areas in the Southeast, numbers per state in each category.

State Parks and Natural Areas (611):

Alabama (24), Florida (157), Georgia (65), Kentucky (41), Louisiana (6 east of the Mississippi River), Mississippi (25), North Carolina (59), South Carolina (47), Tennessee (55), Virginia (95), West Virginia (37).

State Forests (118):

Alabama (6), Florida (35), Georgia (8), Kentucky (7), Louisiana (0 east of the Mississippi River), Mississippi (2), North Carolina (9), South Carolina (6), Tennessee (15), Virginia (21), West Virginia (9).

Miscellanea

Reviews

A New Flora for an Old Dominion

Alan S. Weakley, J. Christopher Ludwig, & John F. Townsend. 2012. Flora of Virginia. Bland Crowder (ed.). Foundation of the Flora of Virginia Project Inc., Richmond, VA. Published by the Botanical Research Institute of Texas Press, Fort Worth, TX. 1,554 pp. Hardcover $86.00. ISBN978-1889878-38-6.

The new *Flora of Virginia* represents perhaps one of the longest sustained efforts at producing a state flora on record. Like most complete flora manuals, it represents a rich history of the lives and exploits of many who spent over 250 years in the field and laboratories of most of the Commonwealth's scientific institutions as well as the eastern half of the United States.

Timing is everything and the talents and leadership of Alan S. Weakley, J. Christopher Ludwig, and John F. Townsend have come together in a new flora of an Old Dominion. Not only did the authors have the organizational skills as well as the botanical expertise, they also had the personalities to attract the talents of Virginia's best traditional team of botanists, technicians, and institutions as the acknowledgements show.

The early section of the book is comprised of a very complete history of botanical exploration of Virginia from times of pre-Colonial exploration to the present. For those who appreciate the Commonwealth's history, the first chapter by Nancy Ross Hugo and Donna Ware is revealing as it connects prominent early Virginians with the landscape in which they traveled in stories that most historians would find worth the price of the book.

Gary Fleming's following chapter on The Nature of Virginia's Flora is a must read treatise on the evolution of Virginia's forests from late Pleistocene to present and should be required reading for every student of the Natural Sciences in the region. It not only defines the botanical communities, but also forms the basis for all of the Commonwealth's ecosystems for both plants and animals.

The keys are easy to use and the complete glossary makes the work palatable to both amateur and professional botanists alike. Very few anatomical descriptions in the keys cannot be viewed with a 15x hand lens.

Descriptions of individual species are very complete whereas some new state floras use little other than the keys for a plant description. County distribution dot maps would have created a better visual distribution of each species, but the information is available on-line in The Digital Atlas of the Virginia Flora, a collaborative work that is easy to use. Having said that, there are likely those of us who will still drag our dog-eared, time worn, easily carried, hard copies of the *Atlas of the Virginia Flora* through the field with us as we seek out new county records across the state.

The drawings of Lara Call Gastinger, Michael A. Terry, and Roy Fuller give good "signature" confirmations of the plants, but many lack the detail provided in the old Gleason & Cronquist and Godfrey & Wooton texts, where time, resources, and sheer numbers of illustrators were funded and focused on detail, a luxury seldom affordable today. It may be sufficient to say that the work is as good as any currently being produced and that the graminoid and fern drawings are second to none with excellent details of fern sori and clearly illustrated graminoid reproductive parts of perigynia, spikelet, tubercle, and other diagnostic fertile portions of those plants.

Whereas future plans include phone apps. and other more current methods of easily carried versions in the field, the eight pound traditional and classical botanical text will grace the office shelves and herbarium collections of botanical institutions for years to come. The work is a time honored treatise in traditional botany and John Clayton would have been proud to own it.

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Reports

1. President's Report

In January, 2013, I began my two-year term as President of the Virginia Natural History Society. I thank the most recent President, Ralph Eckerlin, for serving as President for the past 2 years and Ollie Flint as Councilor for the past 4 years. The Society has two new officers including Vice President Michael Lachance and Councilor Nancy Moncrief. I thank Bill Shear for his continuing service as Secretary-Treasurer.

The Society's main activity is the semi-annual publication of *Banisteria* and I thank Steve Roble for his continued excellent service as Editor of the journal. The proceedings of the Virginia Natural History

Society's 2009 symposium is presented in this volume. The Society also was represented at the latest meeting of the Virginia Academy of Science in Blacksburg this past May with presentations in the Natural History and Biodiversity section, as well as presentations in the poster section.

As a new leader of the Virginia Natural History Society, I have been thinking about possible ways to engage our membership. We are not a large society, currently with about 75 members (plus 15 institutions), but maybe it is time to consider an annual or semi-annual field trip, perhaps coinciding with our own annual meeting. This would not preclude presentations at the Virginia Academy of Science meeting. Please share your ideas with me about this suggestion through e-mail at tfredericksen@ferrum.edu.

Respectfully submitted
Todd Fredericksen, President
Virginia Natural History Society

2. Secretary-Treasurer's Report

As of June 30, 2013, the society has 87 members, including 15 institutions. This represents a decrease in membership from December 2012 (109 members, 17 institutions). In December 2011, we had 117 members, including 19 institutions. Except for 2011, membership has declined over the past nine years from the most recent high point in 2004, when we enrolled 165 members, including 22 institutions.

Our current bank balance is $9,610.02, up $1,257.02 from six months ago.

The results of the 2013 election of officers are as follows:

President, Todd Fredericksen
Vice President, Michael Lachance
Secretary/Treasurer, William Shear
Councilor, Nancy Moncrief

Respectfully submitted,
William A. Shear, Secretary/Treasurer

3. Joint meeting of the Virginia Natural History Society and the Virginia Academy of Science, May 23, 2013, Virginia Tech, Blacksburg, VA

Through the efforts of Past President Ralph Eckerlin, members of the Virginia Natural History Society were invited to present papers and posters at the 2013 meeting of the Virginia Academy of Science (VAS) without being required to join the VAS. Unfortunately, the response to this trial offer was very limited and attendance during the oral presentations portion of the Natural History and Biodiversity Section of VAS was sparse. The following talks and posters were presented:

Talks:

Least-cost pathways of movement as an aid to predation management on a naturally fragmented landscape. R. D. Dueser, J. H. Porter, & N. D. Moncrief

Free-living soil nematode population dynamics at an *Asimina tiloba* site in Virginia. S. R. Marzec & T. M. Grana

Inventory and conservation assessment of the moth fauna of Virginia (Lepidoptera). S. M. Roble

Developmental tolerance to nicotine differs between incipient species of a parasitic wasp with respect to host food-plant. J. P. Bredlau & K. M. Kester

Habitat characteristics influencing hibernation site selection by the Wood Turtle (*Glyptemys insculpta* Le Conte), a threatened species in the Shenandoah Valley, Virginia. J. A. Miller, W. S. Bousquet, T. S. B. Akre, D. F. Cooper, S. L. Dieudonne, S. L. Kochman, B. E. Ridgeway, V. C. Thomas, & J. T. Walker

Depositional history of the Carmel Church Bonebed, a Miocene (14 Ma) marine vertebrate fossil site in Caroline County, Virginia. A. C. Dooley, Jr.

Posters:

Habitat use and swimming behavior of longnose dace (*Rhinichthys cataractae*) from a mercury contaminated river. K. J. Bolyard & J. E. Bennett

Describing nematode diversity. J. A. Dochney, T. N. Mai, & T. M. Grana

Learned responses to herbivore-induced phyto-chemicals in the parasitic wasp, *Cotesia congregata* (Say) (Hymenoptera: Braconidae). C. D. Crockett & K. M. Kester

Migration dynamics of Northern Saw-whet Owls in the Inner Piedmont of Central Virginia. E. M. Stine & E. Sattler

Age and paleo-environmental significance of Upper

Paleozoic Ostracodes from the Appalachian and Eastern Illinois Basins. S. C. Sanders & N. E. Tibert

Turtles of the Fredericksburg Canal: Introduced species and estimates of population sizes. Y. Takeda & W. Wieland

4. Webmaster's Report

VNHS website traffic from 1 July 2012 to 12 June 2013 is summarized in the following table:

Month	Sites	Visits	Pages	Files	Hits
July	855	667	1113	3246	5909
August	634	781	1633	3898	6574
September	603	765	1569	3769	6270
October	574	645	1305	3699	5992
November	813	601	1262	3907	6303
December	568	501	881	2980	5022
January	633	550	926	3189	5284
February	769	524	1093	3890	7646
March	875	612	1284	4258	7899
April	985	617	1037	4237	6914
May	1015	750	1403	4264	7465
June	471	278	489	1805	2886
Total	-----	7291	13995	43142	74164

The Virginia Natural History Society is **no longer** accessible using the url: http://va-nhs.org. The url: http://virginianaturalhistorysociety.com is our current website address.

Respectfully submitted,
John White, VNHS Webmaster

5. Editor's Report

Completion of this issue of *Banisteria* was delayed somewhat to allow for the inclusion of several late additions to the proceedings of the 2009 symposium entitled "Historical Explorations into Virginia's Natural History." I thank Associate Editor Joe Mitchell for his help with the symposium portion of this issue.

I have inaugurated a new section entitled "Viewpoint" to include the essay by Rowland Shelley of the North Carolina State Museum of Natural Sciences. Comparable essays pertaining to regional natural history will be considered for publication in future issues of *Banisteria*.

Due to a printer's error, the back cover illustration was omitted from the previous issue of *Banisteria*. That free hand drawing by the late Richard Hoffman appears on the back cover of this issue.

The next issue of *Banisteria* will feature a summary paper on the cave invertebrate fauna of Virginia. Manuscripts currently in review will likely comprise the first issue of 2014 and help to get the publication schedule back on track.

Note that my mailing address (see inside front cover) has changed effectively immediately.

Respectfully submitted,
Steve Roble, Editor, *Banisteria*

Announcements

1. New web-based atlas of rare Lepidoptera and Odonata of Virginia (www.vararespecies.org)

The Virginia Department of Conservation and Recreation's Division of Natural Heritage has just completed a web-based "Atlas of Rare Butterflies, Skippers, Moths, Dragonflies and Damselflies of Virginia." Developed with funds provided by the Virginia Department of Game and Inland Fisheries through a state wildlife grant from the US Fish and Wildlife Service, this new resource allows the public to quickly access current and accurate information about these rare species in Virginia. Users can search the database by species or common name and obtain a summary of its state and national conservation status ranks, as well as a list of the counties and cities where the species has been observed in Virginia. Likewise, one can search by county or city name for a list of the rare species observed there. The Atlas also includes a printable fact sheet for each species, which includes information about its ecology and life history, identifying characteristics, population trends and potential threats, a county level distribution map, photographs, and more.

2. Recently published

Daniel W. Fong, Megan L. Porter, & Michael E. Slay. 2012. Cave Life of the Virginias: A Field Guide to Commonly Encountered Species. National Speleological Society, Biology Section. 42 pp.

Wendell R. Haig. 2012. North American Freshwater Mussels: Natural History, Ecology, and Conservation. Cambridge University Press, Cambridge, U.K. 505 pp.

Karl B. McKnight, Joseph R. Rohrer, Kirsten McKnight Ward, & Warren J. Perdrizet. 2013. Common Mosses of the Northeast and Appalachians. Princeton University Press, Princeton, NJ. 392 pp.

Virginia Natural History Society

http://virginianaturalhistorysociety.com/

General Information

The Virginia Natural History Society (VNHS) was formed in 1992 to bring together persons interested in the natural history of the Commonwealth of Virginia. The VNHS defines natural history in a broad sense, from the study of plants, animals, and other organisms to the geology and ecology of the state, to the natural history of the native people who inhabit it. The goals of the VNHS are to promote research on the natural history of Virginia, educate the citizens of the Commonwealth on natural history topics, and to encourage the conservation of natural resources.

Dissemination of natural history information occurs through publication of the journal *Banisteria*, named for John Banister (1650-1692) who was the first university-trained naturalist to work in Virginia. The first issue was published in 1992, and the journal is published twice per year in spring and fall. Articles cover a wide array of subjects, and prospective authors are encouraged to submit manuscripts on any aspect of natural history in Virginia; papers may pertain to Virginia or regional archaeology, anthropology, botany, ecology, zoology, paleontology, geology, geography, or climatology. Book reviews, biographies, obituaries, and historical accounts of relevance to natural history in Virginia also are welcomed. Manuscripts are peer-reviewed for suitability and edited for inclusion in the journal.

Page charges ($20/page) are waived if the sole or first author is a VNHS member. All authors must pay $75/page if they desire color printing of figures. The society's website contains detailed instructions for authors and the titles, abstracts or full PDF versions of articles from past *Banisteria* issues.

Memberships

The VNHS is open to anyone with an interest in natural history and welcomes participation by all members in society activities and efforts to promote education and conservation. Membership includes a subscription to *Banisteria* and invitations to periodic symposia and field events. Annual dues for members are $20 (per calendar year); library subscriptions are $40 per year. Checks or money orders (credit cards are not accepted) should be sent to the Secretary/Treasurer, who also has back issues of *Banisteria* available for sale. The VNHS is a tax-exempt, nonprofit, society under Section 501(C)3 of the IRS. We welcome donations to support our mission in Virginia.

Virginia Natural History Society

Application for Membership

Name _____

Address_____

_____

_____

Zip Code _____

Phone _____

Email _____

Area(s) of Interest _____

ANNUAL DUES AND SUBSCRIPTIONS TO *BANISTERIA*

(memberships and subscriptions are by calendar year; subscribers/members outside the United States should add $3.00 for additional postage)

- ☐ $500.00 Life (not annual)
- ☐ $300.00 Benefactor
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- ☐ $25.00 Family
- ☐ $20.00 Regular
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☐ I have added a contribution of $_____ to my membership dues.

The special student rate is applicable only when accompanied by the following certification signed by a faculty advisor.

Institution _____

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Date_____

Make checks or money orders payable to:
Virginia Natural History Society

Send membership form and dues to:
Dr. William Shear, Secretary-Treasurer
Virginia Natural History Society
Box 96
Hampden-Sydney, VA 23943